Aalto University
School of Science
Degree Programme in Media Technology

Kenta Kusumoto

Media Experience of Additional Information on Second Screen

Master's Thesis
Espoo, March 4, 2014

Supervisors: Professor Pirkko Oittinen
Advisor: Teemu Kinnunen D.Sc. (Tech.)

Aalto University
School of Science
Degree Programme in Media Technology

ABSTRACT OF
MASTER'S THESIS

Author:	Kenta Kusumoto		
Title:	Media Experience of Additional Information on Second Screen		
Date:	March 4, 2014	**Pages:**	105
Major:	Visual Media	**Code:**	T-75
Supervisors:	Professor Pirkko Oittinen		
Advisor:	Teemu Kinnunen D.Sc. (Tech.)		

Rapid adoption of new technology such as smartphones and tablets combined with huge growth in media exposure have increased media multitasking, the parallel consumption of different media. This has raised the interest in how people use TV and another screen (e.g. a laptop, smartphone or tablet), the "second screen", together. While most of the second screen usage is unrelated to TV content, a substantial amount of activities that are related to TV content increase the viewers' engagement to the TV. People may for instance share their TV viewing experience on Twitter or search for information on products in a TV commercial. The emergence of tablets has increased the usage of second screen, and brought several dedicated applications, that offer related content to the TV viewer.

This study takes an exploratory approach to investigate the media experience of TV viewing and simultaneous consumption of additional information in a second screen tablet application. A custom second screen application is developed and an experiment simulating a realistic second screen environment is conducted. Several methods including self-reports, psychophysiology, and eye tracking, are used to study media experience.

While additional information did not affect the self-reported media experience of TV programs, psychophysiological recordings suggest that the experience was deteriorated, perhaps, without the participants being consciously aware of it. The results also revealed that additional information worked well with magazine and sports genres. Generally, increased attention on additional information appeared to increase its media experience. The results were associated with potential gratifications of the additional information.

The findings of the study help understand, why people search for TV related additional information, and give directions for improving the media experience of second screens and increase viewers' engagement to TV.

Keywords:	TV, second screen, additional information, media experience, media multitasking, psychophysiology, biosignal, eye tracking, polychronicity
Language:	English

Aalto-yliopisto
Perustieteiden korkeakoulu
Tietotekniikan koulutusohjelma

DIPLOMITYÖN
TIIVISTELMÄ

Tekijä:	Kenta Kusumoto		
Työn nimi:	Second screenilla esitetyn lisätiedon mediakokemus		
Päiväys:	4. maaliskuuta 2014	**Sivumäärä:**	105
Pääaine:	Visuaalinen media	**Koodi:**	T-75
Valvojat:	Professori Pirkko Oittinen		
Ohjaaja:	Tekniikan tohtori Teemu Kinnunen		

Nopea uuden tekniikan, kuten älypuhelimien ja tablet-tietokoneiden, käyttöönotto sekä kasvanut median kulutus on lisännyt usean median rinnakkaista käyttöä. Tämä on kasvattanut kiinnostusta ”second screen” -ympäristöihin eli tilanteisiin, joissa käytetään toista näyttöä TV:n rinnalla. Vaikka suurin osa second screenin käytöstä ei liity TV-sisältöön, huomattavan suuri osa, joka liittyy, sitoo katsojat vahvemmin TV:hen. Ihmiset saattavat esimerkiksi jakaa TV-katselukokemuksiaan Twitterissa tai etsiä tietoa TV:ssä mainostetuista tuotteista. Tablet-tietokoneiden myötä second screen -käyttö on kasvanut entisestään, ja lukuisia TV-ohjelmaan liittyvää sisältöä tarjoavia second screen -sovelluksia on kehitetty.

Tämä tutkimus tarkastelee TV-katselun ja samanaikaisen second screen-sovelluksessa tarjottavan TV-ohjelmaan liittyvän lisätiedon kulutuksen mediakokemusta. Työssä kehitettiin second screen-sovellus ja toteutettiin koe, joka simuloi todentuntuista second screen -ympäristöä. Mediakokemuksen tutkimiseen sovellettiin useita menetelmiä, kuten itsearviointeja, psykofysiologisia mittauksia sekä katseenseurantaa.

Itsearvioiden mukaan lisätiedolla ei ollut vaikutusta TV-ohjelmien mediakokemukseen. Toisaalta kuitenkin psykofysiologiset mittaukset antavat ymmärtää, että katselukokemus huonontui kenties osallistujien tiedostamatta. Lisäksi tuloksista selviää, että lisätieto toimi paremmin ajankohtaisohjelmien ja urheilun rinnalla kuin dokumenttien ja tosi-TV-ohjelmien rinnalla. Lisätietoon kohdistuvan tarkaavaisuuden lisääntyminen vaikutti parantavan lisätiedon mediakokemusta. Tuloksista tunnistettiin mahdollisia lisätiedon gratifikaatioita.

Tämän tutkimuksen tulokset auttavat ymmärtämään, miksi ihmiset hakevat TV:hen liittyvää lisätietoa, sekä tarjoavat suunnitteluohjenuoria second screenien mediakokemuksen parantamiseen ja katsojien sitomiseen vahvemmin TV:hen.

Asiasanat:	TV, second screen, lisätieto, mediakokemus, mediamoniajo, psykofysiologia, biosignaali, katseenseuranta, polykroonisuus
Kieli:	Englanti

Acknowledgements

This work was funded by TEKES as part of the Next Media programme of DIGILE. It was very interesting to see through the programme how media industry of Finland attempts to find opportunities in the rapidly changing media landscape.

I wish to thank my supervisor Professor Pirkko Oittinen for giving me the opportunity to do this work and trusting in me. This work has opened my eyes and provided me new topics of interest outside my small world. I am sure the many things I have learned through this work will help me in the future. I would like to thank my instructor Teemu Kinnunen for the support throughout the work, especially for the valuable feedback and help in the analysis of eye tracking data. I wish to thank Heikki Lindroos for designing and implementing the experiment with me. I would also like to thank Jari Kätsyri for giving me comprehensive guidance in statistical analysis, Jan Kallenbach for teaching me psychophysiology, and all my colleagues at the Department of Media Technology for inspiring discussions.

Finally, I wish to thank my parents Tazuko and Shigeru Kusumoto for supporting me all these years and giving me the opportunity to study. I would like to thank my sister Kaori Uehigashi for guiding me in my studies, and her husband Chitoshi and their daughters Lumina and Nanami for their invaluable support. I would also like to thank our cat Pepi for cheering me up.

Espoo, March 4, 2014

Kenta Kusumoto

Abbreviations and Acronyms

BIS/BAS	Behavioral Inhibition System and Behavioral Activation System
ECG	Electrocardiography
EDA	Electrodermal activity
EMG	Electromyography
EMG-C	Electromyography of corrugator supercilii muscle region
EMG-O	Electromyography of orbicularis oculi muscle region
EMG-Z	Electromyography of zygomaticus major muscle region
ETG	SMI (SensoMotoric Instruments GmbH) Eye Tracking Glasses
GUI	Graphical user interface
HR	Heart rate
IBI	Interbeat interval
MPI	Multitasking Preference Inventory
NS-SCR	Non-specific skin conductance response
OR	Orienting response
RSA	Respiratory sinus arrhythmia
SAM	Self-assessment manikin
SCL	Skin conductance level
SCR	Skin conductance response
U&G	Uses and gratifications theory

Contents

Chapter 1

Introduction

The advancement of technology that has brought new devices such as smartphones and tablets, and increased exposure to various media has increased media multitasking, the practice of consuming multiple media simultaneously. People may read online news on laptop computer while watching TV. Roberts [94] first observed that young people used more than one media at the same time, and later, Foehr [38] concluded that media multitasking is prevalent among the young generation.

Several surveys (e.g. [75]) report that people frequently use devices such as smartphones and tablets while they watch TV. This use of another screen, the second screen, is mostly unrelated to the TV content. Still, a considerable proportion second screen activities is related to TV, and these related activities increase people's engagement to TV. For instance, people may share their thoughts about a TV program in social media, or search for information about people or products that appear on TV.

Through more and more people owning smartphones and tablets, and increase in participation to social media, second screen usage has gradually grown also in Finland. According to a survey conducted by Sonera [98] 27% of the respondents use Internet very frequently while watching TV. The percentage of households having a tablet has doubled from 4% in 2011 [59] to 8% in 2012 [60], and more than doubled to 20% in 2013 [61]. As tablets are particularly suitable as a second screen [29], it can be predicted that the penetration of tablet ownership will increase second screen usage in Finland.

In the hope of increasing TV engagement, TV companies have developed numerous dedicated second screen applications that provide additional content to be consumed alongside the TV program. Most of the second screen applications have evolved through trial and error [88, p. 93], as research on the use of these applications has been small. Anyhow, interest in how to benefit from the media multitasking behavior is large among TV companies and advertisers.

1.1 Motivation

Most of the research on media multitasking and second screens focuses on how these practices affect performance, and the experience aspect has gained very little interest [110]. Most studies (e.g. [39, 83]) agree that multitasking has a detrimental effect on the performance of various types of tasks. However, it is believed that people engage in media multitasking because it is inherently gratifying. For example, people may media multitask in order to avoid boredom [6].

In recent years, several studies on second screens have emerged due to growing interest in them. However, the second screen research has mostly been driven by TV related social media usage and social interactions, and interest towards additional information has been very limited. According to a survey conducted by Walley et al. [112], 52% of the respondents reported that they search for additional information about the TV programs they are watching. This number emphasizes that TV related additional information is an important form of second screen content.

Due to a lack of research in the aforementioned areas, more attention should be given to the experience aspect of second screens, especially to the additional information provided on second screen. This study aims to provide new knowledge in these areas.

1.2 Research questions

This is an exploratory study that aims to identify factors that influence the media experience of TV viewing and simultaneous consumption of TV related additional information presented on a second screen. Media experience of TV viewing and additional information are studied by carrying out an experiment that simulates a realistic second screen environment. Particular focuses are, how the presence of additional information influences media experience of TV viewing and, whether there are differences in media experience of additional information between TV genres. Experience of media is a multifaceted topic. In this study media experience is examined through the Model of Media Experience [48], which is a framework that captures experience of media from various dimensions. Furthermore, the modulation effects of personality traits, such as polychronicity (i.e. preference for multitasking) and BIS/BAS (i.e. responsiveness to positive and negative cues) are accounted. These topics are studied through the following research questions using various methods including self-reports, psychopshyiological recordings, and eye tracking.

RQ 1. *What kind of effect does the presence of additional information have on media experience of TV programs?*

RQ 2. *What differences are there in media experience between TV genres, with respect to the presence of additional information? Consequently, are there genres that are better suited for additional information on second screen?*

RQ 3. *What kind of moderation effect do personality traits have on second screen use and associated media experience?*

The results of this study are examined in the light of gratifications obtained from second screen use and additional information. As a way of consuming media, second screen is expected to involve gratifications which can explain motivations of the practice. Therefore, it can be expected that the second screen affects the media experience of TV viewing. Yet, the effects may vary depending on TV genre. The second screen may enhance the media experience in one genre, and distract in another genre. The influence of personality traits is an aspect that is not accounted very often in media research. Although, personality traits have been studied comprehensively from the perspective of performance and preferences, studies associating personality traits to experience are limited. Recognizing the effect that personality traits have on media experience may prove useful when media services become increasingly personalized. Based on the results of this study, gratifications of additional information presented on a second screen are explored, and recommendations regarding the second screen and additional information given.

Chapter 2

Related work

This chapter describes relevant media related research frameworks including the Model of Media Experience and the uses and gratifications theory, and methods used in this study. The chapter begins by introducing general aspects of media multitasking, the practice of using more than one media simultaneously. Media multitasking is a central concept to this study as it obviously has implications to second screen use which is, as such, a form of media multitasking. The research frameworks that were used, namely, the Model of Media Experience and the uses and gratifications theory, are explained. Furthermore, theories of human attention, emotion, and personality traits, relevant concepts to media psychology research, are discussed. Finally, objective methodologies used in this study to measure attention (heart rate) and emotion (skin conductance and facial electromyography) as well as visual attention (eye tracking), are described.

2.1 Media multitasking

According to Lee and Taatgen [69], multitasking is a human ability to handle multiple tasks simultaneously. Within the context of media, media multitasking is defined as the practice of participating in multiple exposures to several media forms simultaneously [5] (for a comprehensive review on media multitasking, see [110]).

Media multitasking is prevalent, particularly, among young people [38]. According to Brasel and Gips [18] younger people also obtain higher enjoyment from media multitasking, although it is unclear whether the observed generational differences in media multitasking are driven by age-related changes in perception and cognition, or whether they simply reflect varying adoption rates of different technologies. Media multitasking has reported to be increasing together with increased exposure time to media [93].

The relationship between different tasks that are multitasked may vary from complementary to unrelated. D'heer et al. [30] conducted a study on people using multiple screens in living room environment and found that in most cases the second screen use was unrelated to TV content. The second screen was used particularly to avoid watching TV content considered uninteresting. However, participants also extended discussions of TV content into online social spaces and searched for TV related information.

Foehr [38] found that girls between ages of eight and eighteen tended to multitask with various media more than boys of the same age. However, contrary to common belief, studies have showed that there are no gender differences with regards to multitasking performance [19]. D'heer et al. [30] found in their survey that younger participants and male participants more likely owned a tablet, thus enabling certain multitasking behaviors at a wider rate in their respective groups.

It is well known that multitasking has a negative effect on the performance of various types of tasks. Ophir et al. [81] found that heavy multitaskers perform poorly on cognitive control exercises as they are more easily distracted than light media multitaskers. Compared to light multitaskers, heavy media multitaskers are inferior at filtering irrelevant information, memorizing, and task switching. In addition, Ophir et al. [81] believe that chronic media multitasking may even lead to cognitive deterioration.

Experience related to multitasking has not often been the focus of interest in media multitasking research [110]. Bardhi et al. [5] found that media multitasking is associated with both positive and negative experiences. The positive effects, they identified, were efficiency, engagement, control, assimilation, and connectivity. Media multitasking process was a hedonic experience leading to increased engagement with media. Among the negative effects were chaos, inefficiency, disengagement, and enslavement. Disengagement occurred due to reduction in involvement with messages. Furhermore, they found media multitasking to be potentially addictive.

Media multitasking has been studied with various methods including ones employed in this study. Novak et al. [77] used psychophysiological measures such as heart rate and skin conductance to study task switching and dual tasks. Brasel and Gips [18] studied gaze behavior with regards to multitasking activities on multiple screens. There are also several survey instruments that can measure the level of polychronicity, the preference for multitasking [110]. Ophir et al. [81] developed the Media Multitasking Index (MMI) for gathering data on practices of combining media, and to differentiate between groups of low media multitaskers and high media multitaskers. Finally, Iqbal et al. [53] studied motivations for multitasking through a questionnaire.

2.2 Second screen

According to a survey by Nielsen [75], 85% of tablet and smartphone owners use their devices while watching TV at least once a month and 40% report doing it daily. Tablets are considered suitable as TV second screens as they are easier to use and offer better experience over laptops and smartphones in a living room context [29]. While interactive TV can provide the same functionality as a second screen, presenting interactive content on a second screen is considered to be less distracting [27].

Second screen use is mostly unrelated to TV content. However, the second screen use that is related to TV content has drawn the interest of TV companies as it is thought to increases the viewers' engagement to TV [76]. While most attention has been given to TV related social media activity, it is evident that searching for TV related additional information is a crucial form of second screen use. For instance, a survey by Red Bee Media [112] reports that 52% of the respondents have used a second screen to find TV program related information.

Numerous commercial second screen applications that offer TV related additional content have been developed. Although these applications have evolved mainly through trial and error [88, p. 93], some application developers such as Miso [74] conducted a user study and reported the findings. They explored the user experience of additional information in different TV genres using their Miso Sync second screen application. They found that particular type of information suited given genres better, for instance, quotes for comedy, gossip for reality, statistics for sports, and Wikipedia articles for news. Information about people appearing on the TV program worked across genres. There were also differences in preferred frequency of information depending on genre. Participants wanted the least amount of information in scripted drama and the most in unscripted TV programs. Moreover, participants wanted to receive additional information during the slow moments of the TV program and during commercial breaks. Notably, additional information was found to have an effect on TV program engagement before, during and after the TV program.

In academia, Robertson et al. [95] did pioneering work by building a prototype second screen application that helped people in search of a house. Their system displayed pictures and videos of houses on a TV screen, and provided details of the houses on a personal digital assistant (PDA). Fallahkhair et al. [36] built a mobile phone application that supported the user in language learning by providing context relevant learning material of foreign TV programs. The application offered learning material before and after the TV program as well as synchronized material during the TV program. The material could be saved for later use. Moreover, the applications gave summaries of TV programs and the type of the summaries

differed depending on the genre of the TV program. Back in 2008, Cesar et al. [22] developed the first tablet application that enabled social interactions and provided additional information about TV programs in an electronic program guide (EPG). More recently, Basapur et al. [7] developed a browser-based second screen application that enhanced TV viewing by offering related additional information, comments from social networking sites, and related multimedia, on the second screen. They conducted a field trial with the application and observed that additional information improved engagement in the TV program during and after the program but different participants preferred different information. They found that additional information worked better with TV programs that have breaks during which the participants had a chance to look at the information. In contrast, during programs with continuous intense plot some participants choose to ignore the additional information altogether while some participants opened tabs for later exploration, bookmarked websites, or even took notes.

2.3 Model of Media experience

Media is a multifaceted and vague concept as it may refer to, for example, content, device, or channel. In the present study, media refers to content. Different media have different properties which all contribute to how the media is experienced. Several instruments have been developed to measure various aspects of media experience including (but not limited to) engagement [79], flow [78], spatial presence [111], social presence [13], emotion [91], and user experience [1]. Each of them captures unique perspectives of media experience, but also involve overlapping aspects.

Media experience was measured in this study with a questionnaire set inspired by the Model of Media Experience [48] shown in Figure 2.1, as the model is able to capture various dimensions of media related experiences (broadly, the feeling, the appraisal and the interaction dimensions), and relationships between the dimensions.

The Model of Media Experience comprises of three levels, namely, meta, macro and micro levels. The meta level considers how societal, economic and technological changes affect media use, emergence of new media products, and development of novel methods for studying media experience. The macro level addresses the social aspect of media use. Finally, the micro level that is relevant to this study, represents various dimensions of media experience at individual level including everyday media usage, interaction with media, how media feel, and evaluation of media content. On top of media properties, the micro level also considers motives, context of use, user personality traits, and user values.

The Model of Media Experience framework includes a comprehensive set of

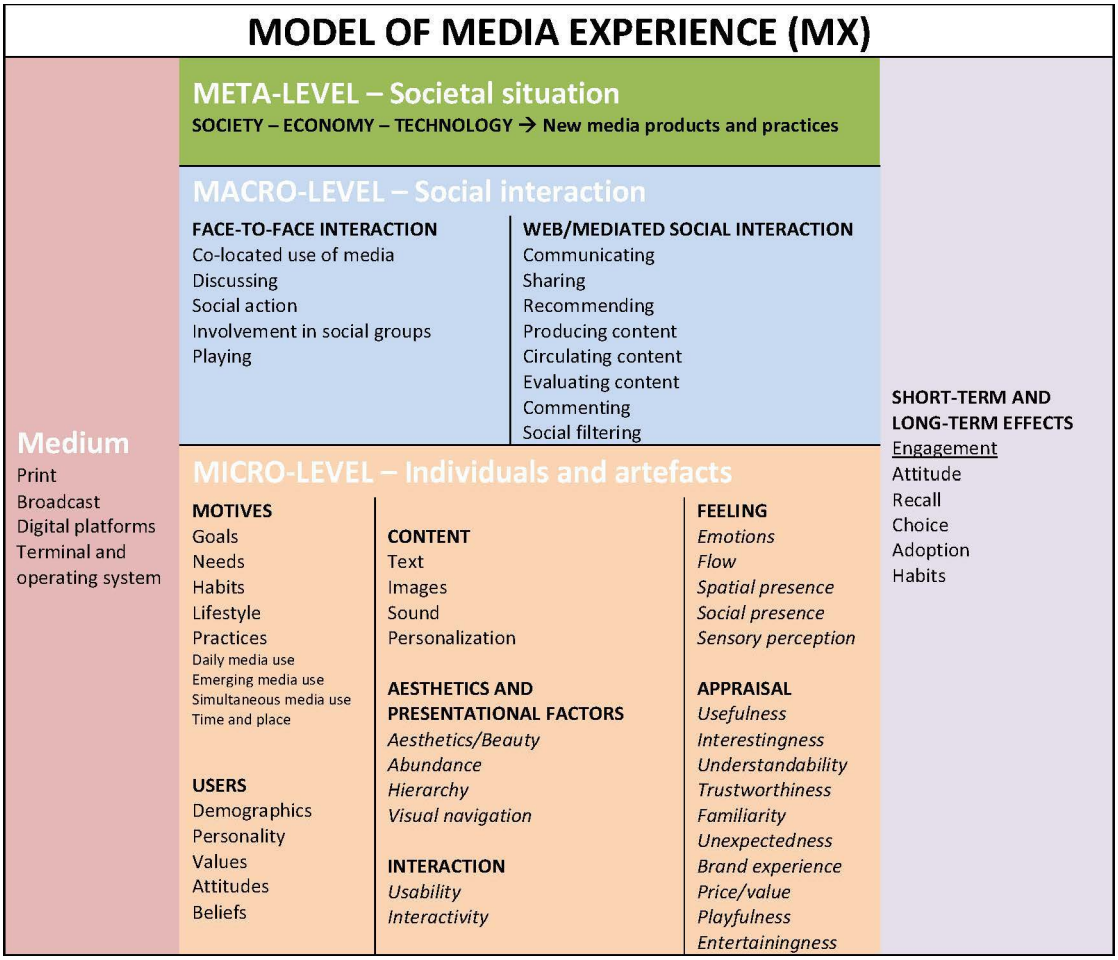


Figure 2.1: The model of media experience [48].

self-report measures that contain 78 items in 16 dimensions, as shown in Table 2.1. The items are adapted from various established questionnaires.

Furthermore, Helle et al. [48] recommends that, when the model is applied to a media study, not all dimensions and methods should, or could be used in the same study. Instead, one should select dimensions and methods that are appropriate for the research questions or theoretical and practical interests.

2.4 Uses and gratifications

Uses and gratifications theory (U&G) [57] has its origins in communication studies, and has been used in the context of media studies to explain motivations behind

Table 2.1: The dimensions of micro level media experience [48].

AE: Aesthetics and presentational factors	A: Spatial presence (attention allocation)
USE: Usefulness	B: Brand
ENT: Entertainingness	F: Familiarity
USA: Usability	PV: Price/Value
Un: Unexpectedness	Ia: Interactivity
P: Playfulness	U: Understandability
T: Trustworthiness	E: Emotions
INT: Interestingness	SP: Sensory perception

media use. Instead of seeing media consumers as passive audience, the theory assumes active audience that select media, which they expect fulfill their innate needs. The original formulation of the theory identifies cognitive needs, affective needs, personal integrity needs, social needs, and tension-release needs, to be driving media use. Recently, Sundar and Limperos [104] questioned the assumption that all gratifications are born out of innate needs, and proposed that affordances of media technology can shape user needs, particularly with new media. This has implications to the present study in that the second screen context as such may give rise to spontaneous needs.

U&G may shed light on the media experience of second screen provided that it may explain motivations behing second screen use as a form of media consumption. While studies on gratifications of second screen usage are few, some studies have identified gratifications that are relevant to the case of second screen and additional information. As with media multitasking, Brasel and Gips [18] found that concurrent TV and computer usage are associated with habitual needs. Baron [6] found that media multitasking involves affective needs such as avoidance of boredom. Furthermore, Wang and Tchernev [113] discovered that, while cognitive needs are the most common drivers of media multitasking behavior, they are seldom satisfied. Then again, affective needs may be satisfied even though they are not actively sought. There is also evidence that second screen usage leads to social and personal integrity needs to be fulfilled [7]. Information multitasking behavior such as web searching has been associated with cognitive needs [103]. Although, it may be trivial, it is safe to assume that cognitive needs are identified also in additional information consumption in a second screen environment [70, 115].

2.5 Personality traits

2.5.1 Polychronicity

Polychronicity is defined as individual's preference for multitasking [86]. König and Waller [62] have explicitly differentiated polychronicity and multitasking by stating that polychronicity is the preference for doing several things at the same time, whereas the behavioral aspect of polychronicity is multitasking.

Research has mainly concentrated on the effect of polychronicity trait on multitasking performance, and less so on its effect on experience. Nevertheless, as König and Waller [62] notes, the relationship between polychronicity and multitasking performance is a controversial topic. Some studies have found a positive relationship [25], some a negative relationship [26] and some no relationship at all [84].

Bluedorn [14] have found a positive relationship between polychronicity and extroversion personality traits, a finding that is also supported by Conte and Gintoft [25]. Extroverts tend to engage in several external activities because they are able to process several stimuli at the same time [35]. Extroverts are thought to either possess more processing resources or they are better at allocating their resources than introverts [105].

Several survey instruments have been developed to measure the level of polychronicity. Two standard questionnaires include the Inventory of Polychronic Values (IPV) [15] and the Modified Polychronic Attitude Index 3 (MPAI3) [58]. Both IPV and MPAI3 contain a cultural aspect which has roots to the original formulation of the polychronicity concept. However, König and Waller [62] suggests that the cultural aspect should be discarded as the role of culture as a predictor of polychronicity is elusive. A more recently developed questionnaire, the Multitasking Preference Inventory (MPI) Poposki and Oswald [86] (Table B.3), does not include the cultural aspect.

2.5.2 Behavioral inhibition and activation systems

The dispositional Behavioral Inhibition System (BIS) and Behavioral Activation System (BAS) are believed to be the two primary brain motivational systems that underlie behavior and affect [45]. BIS regulates aversive motivation and controls the experience of anxiety in response to signals of punishment, non-reward, and novelty. BIS is associated with increased arousal and attention toward the negative cue. BAS, in turn, regulates appetitive motivation and responds to signals of reward and non-punishment, and it may elicit increased arousal and attention toward the positive cue.

The BIS and BAS traits have several implications on feelings and behavior. According to Gray [44], because high BAS individuals have higher impulsiveness they tend to concentrate less on low-immersive media stimuli, experience lower level of presence, and may engage more in distracting stimuli. Thus, attentional distraction and a secondary task may have a larger effect on their feelings. In comparison, individuals with high BIS concentrate more on low-immersive media stimuli and experience higher state of presence.

A commonly used questionnaire to measure the strength of BIS and BAS traits is the BIS/BAS scales (Table B.2) developed by Carver and White [21]. The scales measure BIS sensitivity and three aspects of BAS sensitivity, namely, striving for desirable ends (BAS Drive), positive responses to the occurrence or anticipation of reward (BAS Reward Responsiveness), and tendency to seek out new potentially rewarding experiences (BAS Fun Seeking).

Foehr [38] has shown that sensation seeking (akin to BAS Fun Seeking) trait is a significant predictor of multitasking. Individuals with high sensation seeking trait have a better focused attention, and thus, do better in selective attention tasks for which certain stimuli must be attended while others must be ignored [4]. Low sensation seekers, in turn, perform better in tasks that require them to divide their attention to several stimuli. This is supported by a study conducted by Martin [72] in which low sensation seekers were better at distributed attention in a concurrent reading and listening task. However, Rowland et al. [97] have found that high sensation seekers engage in more parallel activity than low sensation seekers while watching TV. The relation of sensation seeking trait to multitasking may be explained also in terms of the uses and gratifications model which proposes that social and psychological needs lead to specific patterns of media or content usage [57]. Moreover, Perse [85] has found that high sensation seekers are more likely to watch TV accompanied by distracting activities and change channels more often to seek arousing content.

2.6 Media psychology

2.6.1 Attention

Within media psychology, attention is defined as the allocation of limited mental resources to a specific stimulus [52]. In general, theories of attention have selective or capacity aspects [90]. Selective attention refers to selecting certain stimuli for processing while ignoring others, and this process can be either involuntary (orienting) or intentional. Capacity theories, in turn, state that people have a fixed pool of attentional resources that are allocated to different stimuli. It is evident that attention has both aspects [90].

Orienting response (OR) is a central concept in many media studies using psychophysiological methods [90]. Öhman [80] has proposed an information processing model that states that the OR reflects the selection of the eliciting stimulus for processing in a channel with limited cognitive resources. OR is associated with psychophysiological changes such as phasic heart rate (HR) deceleration and increase in electrodermal activity (EDA).

Furthermore, the limited capacity approach states that resources are allocated to three continuously and simultaneously occurring subprocesses, namely, encoding, storage and retrieval [64]. In order to cognitively process a media message, information in the message is encoded, previously stored information is retrieved and compared to the current message, and the new information is stored in the long-term memory. The approach suggests that OR elicited by a media message results in an increased allocation of cognitive resources to the encoding subprocess. If more resources are allocated to a given subprocess, the other subprocesses may be affected, depending on whether the processing system is overloaded.

2.6.2 Emotion

Emotions are biologically based action dispositions that have an important role in the determination of behavior [66]. Most theorist agree that emotions comprise of three components, that is, the subjective experience (e.g. feeling angry), the expressive component (e.g. severe frown), and the physiological component (e.g. sympathetic activation) [90]. On top of that, others aldo include motivational state, action tendency, and cognitive processing [101].

The dimensional theory of emotion suggests that all emotions can be located in a two-dimensional space as coordinates of valence and arousal, as shown in Figure 2.2a [66]. The valence dimension refers to the hedonic quality or pleasantness of an affective experience, and ranges from unpleasant (negative) to pleasant (positive). The arousal dimension refers to the level of emotional activation experience ranging from very calm or sleepy to very excited or energized.

Later, Cacioppo et al. [20] have suggested that instead of one continuous dimension, the positive and negative valences should be considered as two independent dimensions. Some theorists see that the two orthogonal dimensions of emotional experience are the negative activation (NA) and the positive activation (PA) which form a 45° rotation of the original axes, as illustrated in Figure 2.2b [114]. The NA axis extends from highly arousing negative emotion (e.g. fear or anger) to low-arousal negative emotion (e.g. depressed affect or boredom), whereas, the PA axis ranges from highly arousing positive emotion (e.y. joy or enthusiasm) to low-arousal positive emotion (e.g. pleasant relaxation).

Emotions are important to media research, given that emotions have an intimate relationship with the four primary goals of media media messages, that is,

(a) The valence–arousal dimensions (adapted from [114]).

(b) The PA and NA dimensions (adapted from [68]).

Figure 2.2: Two theories of emotion.

to attract attention, to be remembered, to entertain, and to persuade [90].

In psychological studies, a common instrument for measuring the emotional response is the self-assessment manikin (SAM) (Table B.4) developed by Lang [65]. SAM is a non-verbal pictorial scale that can directly assess the pleasure (valence), arousal (emotional activation) and dominance (degree of control) in reaction to an object or an event.

With regard to psychophysiology, facial electromyography (EMG) that measures the contraction of facial muscles is used as an index of valence, while, electrodermal activity (EDA) that measures the level of sweat on the skin is often used to index arousal [90].

2.7 Psychophysiology

Psychophysiology investigates the changes in the activity of physiological systems caused by psychological input [107]. Several psychological processes related to attention, information processing, and emotion, that are central to media research, can be assessed by psychophysiological recordings. Some advantages of psychophysiological measurements compared to self-reports are that they can be performed continuously during message presentation, are not dependent on language, do not require memorizing and do not interfere with message processing [90]. Psychophysiological measures may also provide information on emotional

responses that are not available to the person's conscious awareness. However, psychophysiological measures seldom have a straightforward relation to psychological constructs. Moreover, the strength of association between a physiological event and a psychological event is typically not very high. Due to these possible issues, Ravaja [90] advices using a combination multiple measures. Psychophysiological recording methods presented in this section can be used to measure attention (heart rate) and emotions (skin conductance and facial electromyography) described in Section 2.6.

2.7.1 Heart rate

Heart rate (HR) is the measure of how many times the heart beats in a minute. The most common way to measure heartbeats is to measure the electrical potential changes originating from the heart's cardiac cycle. Recording of these electrical potential changes is called electrocardiography (ECG). HR has proven to be useful in media studies as it is associated with a number of processes important in media research, such as attention, effort, arousal and emotion [90]. HR has been shown to be a good measure of both short-term attentional and long-term effort.

Heart is dually innervated by both the parasympathetic and sympathetic nervous system. This implies that HR carries information on both parasympathetic and sympathetic activity. Increased parasympathetic activity, associated with information intake, attention and approach behavior, causes the heart to slow down [87]. In contrast, increased sympathetic activity, associated with emotional arousal, general preparation for action and mobilization of various types of resources, causes the heart to speed up [102]. As both systems may be active simultaneously, the interpretation of HR may entail interpretative difficulties [90].

Because of the multiple modes of autonomic control in heart, HR may not always work as a valid measure of attention in media studies. For example, film clips depicting highly exiting sports games have been shown to evoke cardiac acceleration [47], apparently reflecting emotional arousal instead of attention [90]. Ravaja [90] suggests that this ambiguity could be avoided by using respiratory sinus arrhythmia (RSA), the respiratory-locked oscillations in HR [87]. RSA has been found to be highly sensitive to changes in attention. It is often quantified by the high-frequency component of heart rate variability (HRV), more specifically, the frequency band of 0.15-0.40 Hz [12].

2.7.2 Skin conductance

Skin conductance (SC), also called elecrodermal activity (EDA), is an excellent measure of the activation of the sympathetic nervous system [28]. EDA gives information about the electrical conductance of the skin that is related to the level

of sweat in the eccrine glands, and in turn, the neural control of the human sweat glands is entirely under sympathetic control. Thus, EDA can be considered as an excellent operational definition of arousal. EDA can be used to index several different processes such as activation, attention, and task significance or affective intensity of a stimulus [90].

EDA yields both tonic and phasic components, that is, skin conductance level (SCL) and skin conductance response (SCR), respectively [90]. SCL usually refers to long-term averages or base levels of conductance and they reflect the ebb and flow of information-processing capacity to a stimulus or involvement in a stimulus [51]. SCRs are short-lasting changes in EDA [17]. They may be elicited by distinct stimuli or may occur in the absence of obvious external stimuli, in which case, they are called non-specific skin conductance responses (NS-SCR). Counting the rate of NS-SCRs per minute yields another tonic measure of EDA [90]. Media researchers have used tonic EDA to index arousal.

Usually, EDA is measured by placing Ag/AgCl electrodes on the volar phalanges of fingers of the non-dominant hand [17]. The distal phalanges of the fingers are preferred because of their greater responsiveness [100] and greater sweat gland activity as compared to the medial and proximal phalanges [40]. In case, both hands are unavailable (e.g. they are needed for performing a task), the electrodes can be placed on specific sites on the foot [32].

2.7.3 Facial electromyography

Facial electromyography (EMG) measures the electrical activity associated with the contractions of the facial muscles [106], an important form of emotional expression. Facial EMG can identify subtle reactions to emotional media that may not be perceptible using the facial expression coding methods [16]. The facial EMG has been shown to be able to primarily discriminate positive emotions from negative emotions [67]. Activity at two facial muscle regions, namely, the zygomaticus major (cheek) and corrugator supercilii (brow), as illustrated in Figure 2.3, has been associated with positive emotions and negative emotions, respectively. In addition, activity at the orbicularis oculi (around the eye) muscle area is thought to be involved in the expression of enjoyment smile and genuine pleasure [34]. The facial EMG is usually measured using Ag/AgCl miniature electrodes placed on the left side of the face on the aforementioned muscle regions [90].

The use of the facial EMG in media studies has shown that corrugator activity can be used as a valid indicator of negative emotional responses, whereas some caution may be needed in using zygomatic activity as an index of positive emotional responses, especially, when less extreme emotional messages are presented [90]. Orbicularis activity is potentially useful measure of positive emotional responses but orbicularis activity may increase also during high-arousal stimuli.

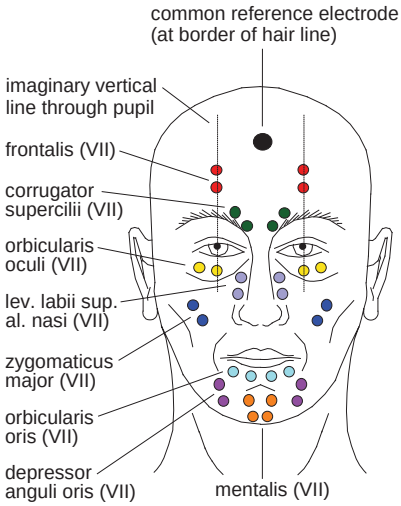


Figure 2.3: The placement of EMG electrodes [109].

2.8 Eye tracking

Eye tracking is a method used to measure the point of gaze by detecting the eye movement [48]. Eye tracking provides information about visual attention and thus may give insight into what the person found interesting. This is useful in media experience research, particularly, when combined with other methods such as psychophysiological measurements [90]. By synchronizing the eye movement data with the psychophysiological data, it is possible to perform a fine-grained analysis of the relationship between the visual elements of a media message and physiological responses.

There are several approaches for tracking the eye movement, most popular being the detection of corneal reflections of infrared light [46]. A notable advantage of using infrared light is that it is invisible to human eye and thus do not distract the subject or cause pupil contraction.

The primary requirement of eye movement analysis is the identification of three types of events, namely, fixations, saccades, and smooth pursuits [31, p. 47]. Fixations stabilize the eyes over a stationary object of interest, saccades are rapid eye movements that reposition the eyes over a new location, and smooth pursuits occur when eyes follow a moving object. Fixations have been used to, for instance, to measure interest and informativeness [41]. It is often assumed that fixations reflect attention. However, as it has been shown that people sometimes remember objects they have not fixated on, this assumption may not always hold [50, p. 71].

Chapter 3

Experiment

This chapter reports of the technical and procedural aspects of the experiment that was conducted to identify the factors that affect media experience of TV viewing and second screen use. Media experience was measured by employing several methods described in Chapter 2. The setup of the experiment simulated a realistic second screen environment, in which the participant interacted with a custom built second screen application while watching TV (Figure 3.1). The second screen content comprised of TV program related tweets and additional information.

Figure 3.1: The participants interacted with the implemented second screen application while watching TV.

3.1 Design

The experiment had a $8 \times 2 \times 2$ mixed design with the following independent variables: TV programs, the presence or absence of tweets, and the presence or absence of additional information. The dependent variables consisted of self-reports that measured the media experience of TV programs, tweets, and additional information, multitasking related self-report variables, tablet interaction logs, psychophysiological measures, and eye tracking data. In addition, moderation effects of the participant polychronicity were studied.

3.1.1 Independent variables

The independent variables were the TV programs, the presence or absence of tweets, and the presence or absence of additional information. TV stimuli consisted of eight approximately five minutes long TV program clips belonging to four different genres, which implies two programs per genre (Table 3.1). All participants watched all of the programs.

Table 3.1: The labels, program names, and genres of the programs (for details, see Table A.1). The labels are used throughout this thesis.

Label	**Name**	**Genre**
ORPHANAGE	MOT	Magazine
MINE	Suora linja	
NATURE	Avara luonto	Documentary
LOVE	Totuus rakkaudesta	
CAR	Latela	Reality
DANCE	Pakko tanssia	
BOXING	Boxing	Sports
FLOORBALL	Floorball	

Conditions and condition sets

The presence of tweets (TWEETS) and the presence of additional information (ADDINFO) in different combinations formed the experiment conditions, shown in Table 3.2. Furthermore, the TV programs were presented with different condition combinations arranged in four different condition sets, as Table 3.3 demonstrates, and the participants were assigned different condition sets. The combination of tweets and additional information presented with a TV program was the same in

Table 3.2: The experiment conditions and the combination of contents as well as the presence of additional information in each condition.

Condition	**Content combination**	**Addinfo**
1	TV only	Absent
2	TV + tweets	Absent
3	TV + addinfo	Present
4	TV + tweets + addinfo	Present

Table 3.3: The condition sets and conditions they are comprised of (for conditions, see Table 3.2).

Condition set	**TV program condition**			
	ORPHANAGE & MINE	NATURE & LOVE	CAR & DANCE	BOXING & FLOORBALL
1	1	2	3	4
2	4	1	2	3
3	3	4	1	2
4	2	3	4	1

a particular condition set. However, the presentation order of the TV programs was randomized for every participant.

As an example, in case a participant was assigned the Condition set 1, then the participant was presented the programs ORPHANAGE and MINE without any tablet content, NATURE and LOVE with tweets only, CAR and DANCE with additional information only, and BOXING and FLOORBALL with both tweets and additional information.

Moderator variables

Moreover, moderation effects of participant polychronicity were studied. Polychronicity was measured with a polychronicity index which is simply the sum of the Multitasking Preference Inventory (MPI) [86] items (Table B.3). Other possible moderator variables, such as the BIS/BAS indices [21], age, and gender, were omitted as they did not not show any notable effects.

3.1.2 Dependent variables

The dependent variables consisted of media experience self-report variables adapted from the Model of Media Experience [49], tablet interaction logs, psychophysiological measures including ECG, EDA, and three facial EMGs, and the proportion

of total fixation duration on the tablet[1] as an eye tracking measure. While the psychophysiological variables were measured in all conditions, the eye tracking variable was measure only in conditions in which tablet content was presented (Condition 2, Condition 3 and Condition 4).

Media experience self-reports

In order to measure media experience, self-report items were selected from appropriate media experience dimensions (Table 2.1). Media experience was measured separately for each content, namely, the TV (Table 3.4), tweets (tweets are not discussed in this thesis), and additional information (Table 3.5), with different variable sets. TV program related questions were asked in all experiment conditions but additional information related questions were asked only in Condition 3 and Condition 4, in which additional information was presented. Some items were not used as dependent variables because they were outside the focus of this study or did not show any notable effects. Immersion variable was omitted from both the TV and additional information related media experience variable sets because the effects on the variable were almost identical to the effects on the concentration variable in both sets.

Table 3.4: TV program related media experience variables (for all items, see Table B.5), their respective media experience dimensions (for dimensions, see Table 2.1), and their associated question number in Table B.5.

Variable	**Media experience dimension**	**Question**
Interestingness	INT: Interestingness	1
Relevance	USE: Usefulness	2
Trustworthiness	T: Trustworthiness	3
Novelty	Un: Unexpectedness	4
Understandability	U: Understandability	5
Likability	Custom	6
Concentration	A: Spatial presence	7

Multitasking self-reports

Multitasking related self-report variables and the conditions in which they were measured are presented in Table 3.6. "Search willingness" measured whether the

[1]Because diversity of terms refer to the same measure (i.e. the total duration of fixations) in literature, Holmqvist et al. [50, pp. 386–389] recommends using the term "total dwell time", as a consensus. However, in this thesis, "total fixation duration" is used as it is more descriptive.

Table 3.5: The additional information related media experience variables (for all items, see Table B.6), their respective media experience dimensions (for dimensions, see Table 2.1), and their associated question number in Table B.6.

Variable	**Media experience dimension**	**Question**
Interestingness	INT: Interestingness	1
Relevance	USE: Usefulness	2
Trustworthiness	T: Trustworthiness	3
Novelty	Un: Unexpectedness	4
Understandability	U: Understandability	5
Likability	Custom	6
Concentration	A: Spatial presence	7
Valuableness	Custom	9
Experience enhancement	Custom	10
Relatedness	Custom	11

participants would have searched for additional information about a particular TV program, "multitasking effort" measured the effort of attending both screens, "TV–tablet attention" measured the perceived attention distribution between the TV and the tablet, "Tweets–addinfo attention" measured the perceived attention distribution between the tweets and the additional information, "tablet distracts TV" measured how much the tablet was perceived to be distracting the TV viewing, "TV distracts tablet" measured how much the TV was perceived to be distracting the tablet use, and finally, "main screen" measured which of the TV of the tablet was considered to be the main screen.

Table 3.6: Multitasking related variables (for all items, see Table B.7), conditions in which they were measured (for conditions, see Table 3.2), and their associated question number in Table B.7.

Variable	**Conditions**	**Question**
Search willingness	1, 2, 3, 4	2
Multitasking effort	2, 3, 4	3
TV–tablet attention	2, 3, 4	4
Tweets–addinfo attention	4	5
Tablet distracts TV	2, 3, 4	6
TV distracts tablet	2, 3, 4	7
Main screen	2, 3, 4	8

Tablet interactions

Interactions on tablet elements related to additional information (see Section 3.8.5) were logged and used as dependent variables (Table 3.7). Obviously, these variables were measured in Condition 3 and Condition 4, in which additional information was presented. "Opened articles" counted the total number of times additional information articles were opened, "uniquely opened articles" counted the number of opened articles (i.e. not counting when an article is reopened), "bookmarked articles" counted how many articles were bookmarked, and "feed interactions" counted the number of interactions on the additional information feed. All values of the interaction variables were divided by the length of the TV program clips.

Table 3.7: The additional information interaction variables.

Variable
Opened articles
Uniquely opened articles
Bookmarked articles
Feed interactions

Self-reported valence and arousal

The self-assessment manikin (SAM) [65] was used to measure the combined affective experience of the TV and the tablet contents (Table B.4). SAM items were asked in all conditions, and thus, the participants evaluated the combined affective experience of the TV and the tablet contents when any tablet content was presented, and the affective experience of only the TV when no tablet content was presented. With regards to the Model of Media Multitasking, SAM can be projected to the Emotions dimension (see Table 2.1).

Eye tracking

Eye tracking was used to measure the visual attention. The proportion of total fixation duration on the TV screen, the tablet screen, and other locations (i.e. not on either of the screens) were determined. In literature, total fixation duration has been associated with interest and informativeness [41]. However, only the proportion of total fixation duration on the tablet was used as a dependent variable as the proportion of total fixation duration on the TV screen was merely the opposite of the tablet variable, and the proportion of total fixation duration on other locations did not show any notable effects. The number of fixations per minute, and the number of gaze transitions between the two screens per minute

were also calculated, but they were omitted because they did not show any notable effects.

Psychophysiology

Furthermore, psychophysiological measures, namely, IBI (related to HR), number of NS-SCRs per minute (related to EDA), and facial EMGs, were used to measure psychophysiological attention, arousal, and valence, respectively. Three different muscle areas were used for the facial EMGs including zygomaticus major (EMG-Z), orbicularis oculi (EMG-O), and corrugator supercilii (EMG-C), which measure positive affect, high arousal positive affect, and negative affect, respectively.

3.2 Procedure

Prior to taking part in the experiment, the participants were asked to fill an online pre-experiment questionnaire consisting of sociodemographics items (Table B.1), the Multitasking Preference Inventory (MPI) (Table B.3), and the BIS/BAS scales (Table B.2). The sociodemographics items asked about gender, age, educational background, profession, media usage, social media usage, and TV related information search habits.

Upon arrival to the experiment room, the participants were asked to wash their hands with soap and water to avoid unnecessary noise in the EDA signal as the electrodes were attached to fingers. In order to identify potential outliers, the participants filled out a questionnaire that asked about psychoactive stimulant use (i.e. coffee and tobacco) during the previous 24 hours. A brief description of the experiment procedure, the methods, and particularly the use of the SAM scales, were given, after which the participants signed an informed consent form. The participants were not given any specific task but were instructed to watch the TV programs and use the second screen application as they like.

Thereafter, the electrodes for the psychophysiological measurements were attached and sufficient quality of the signals was tested. The participants wore the ETG and headphones, after which the ETG was calibrated and the sound level of the headphones was adjusted to ensure that the participants could hear what was said in the TV programs.

The baselines of the participants with respect to the signals were measured during a five minutes resting period. After the baseline measurement the participants completed a practice task, in which they watched a practice TV program accompanied by both tweets and additional information on the tablet. The practice program was not any of the programs used as stimuli during the actual experiment. All instructions during the experiment were given on the tablet.

Individual trials of the experiment were preceded by a countdown leader presented on the TV to indicate that a TV program was starting. Each time after watching the TV program, the participants were instructed to fixate on a fixation cross presented on the TV. The cross was used to estimate how much the gaze tracking had possibly drifted. After each trial, the participants filled out a questionnaire asking about the media experience of the trial using the tablet.

Upon completing all trials, the participants evaluated the overall experience of the second screen use by filling out a post-experiment questionnaire. Finally, the participants were rewarded two movie tickets and thanked for participation.

3.3 Participants

Only people with normal vision (possibly corrected with contact lenses) were recruited because the eye tracking did not work reliably with prescription glasses. In addition, the participants had to be fluent in Finnish because the stimuli were in Finnish. In total 43 people (32 male, 11 female), mostly undergraduate students at the Aalto University, participated in the experiment. The average age of the participants was 27.43 years (SD = 7.20 years). Most of the participants were in their twenties (Figure 3.2), and had a degree in higher education (Figure 3.3a) and an engineering background (Figure 3.3b).

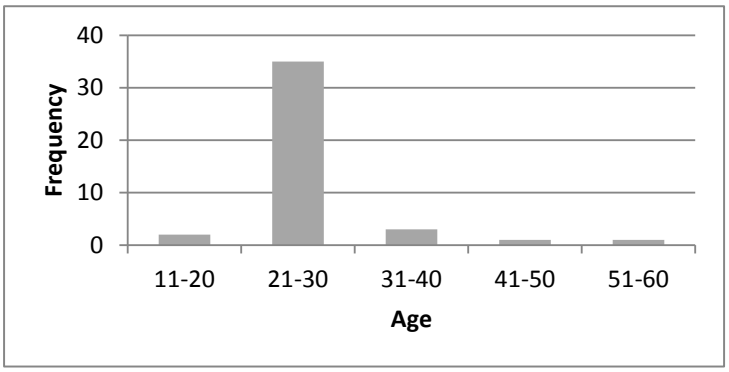
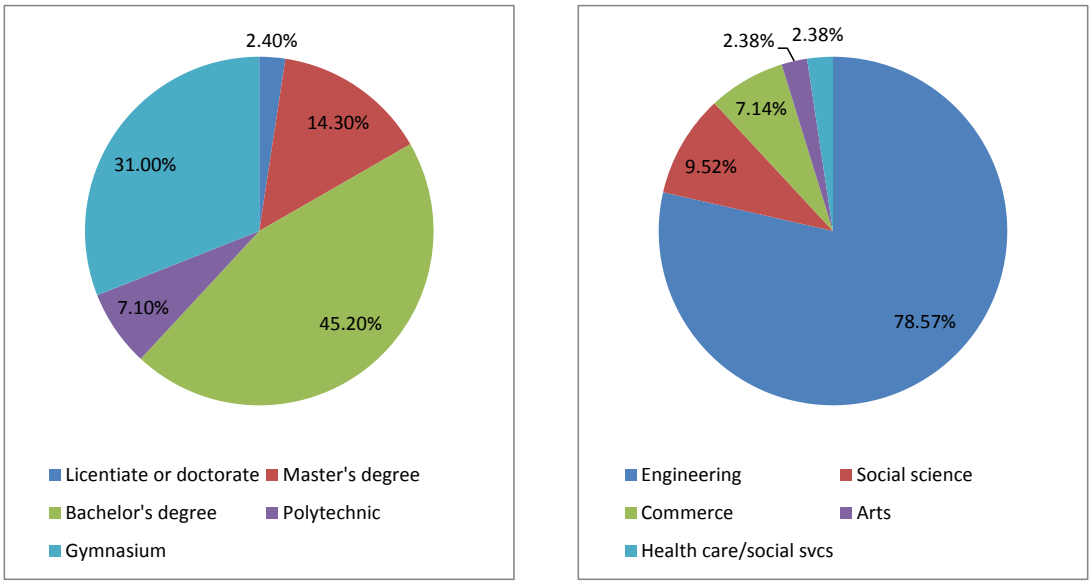


Figure 3.2: Age.

Two thirds of the participants used a computer more than seven hours a day (Figure 3.4), and media more than eight hours a day (Figure 3.5). Two thirds reported that they use a TV (device) to watch TV, and nearly as many reported that they use a computer for that purpose (Figure 3.6). Other notable findings include that one third watched TV on a mobile phone and one fifth did not own a TV at all. One fourth watched TV on a tablet.



(a) Education. (b) Profession.

Figure 3.3: Education and profession.

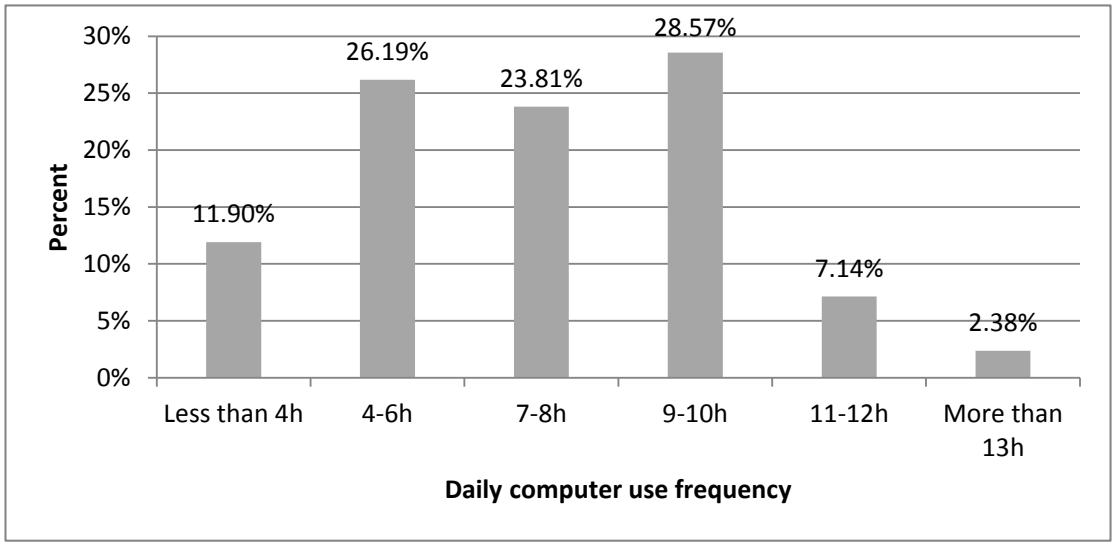


Figure 3.4: Daily computer use frequency.

Remarkably, nearly half (42.86%) of the participants owned a tablet (Figure 3.7). The proportion is substantially larger than the percentage of Finnish households that have a tablet, which according to Statistics Finland [61] was 20% in 2013.

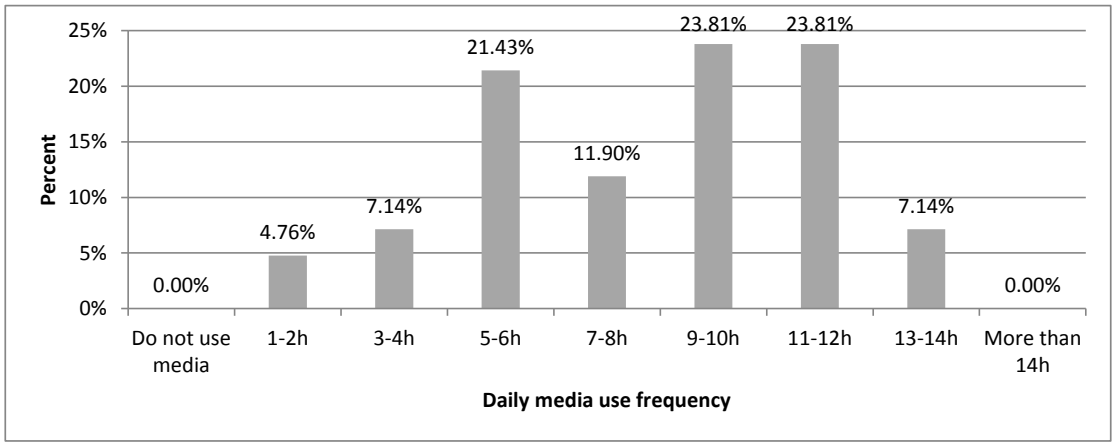


Figure 3.5: Daily media use frequency.

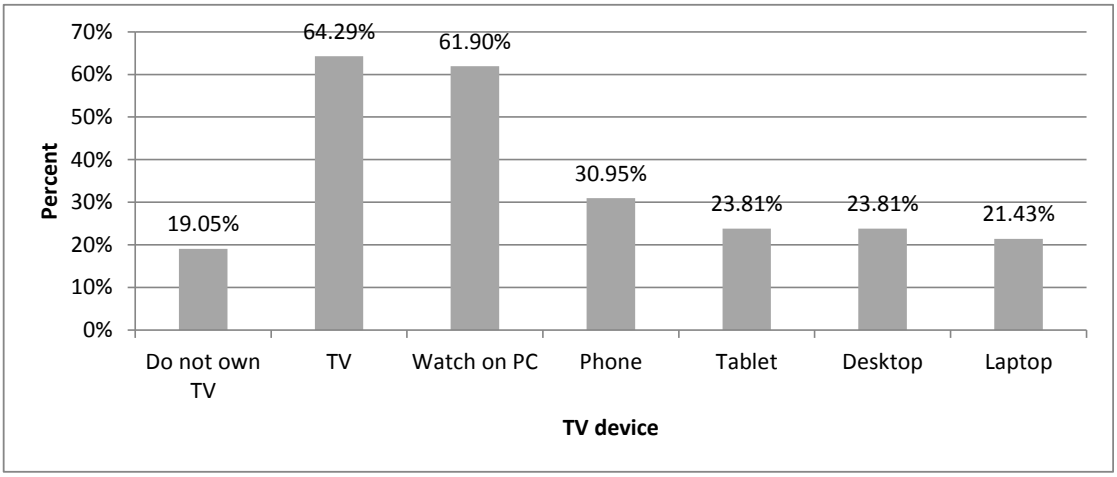


Figure 3.6: Devices the participants use to watch TV.

Over two thirds of the participants used a second screen while they watched TV (Figure 3.8). They estimated that their second screen usage is mostly unrelated to the TV content (Figure 3.9), a finding which is in accordance with the previous studies on second screen usage [29, 43].

More than half of the participants reported that they search for TV content related information at least occasionally (Figure 3.10). Among the services used to search for TV related information, the most popular were web search engines, Wikipedia, IMDb[2], and TV program guides (Figure 3.11). In contrast, for example

[2]http://www.imdb.com/

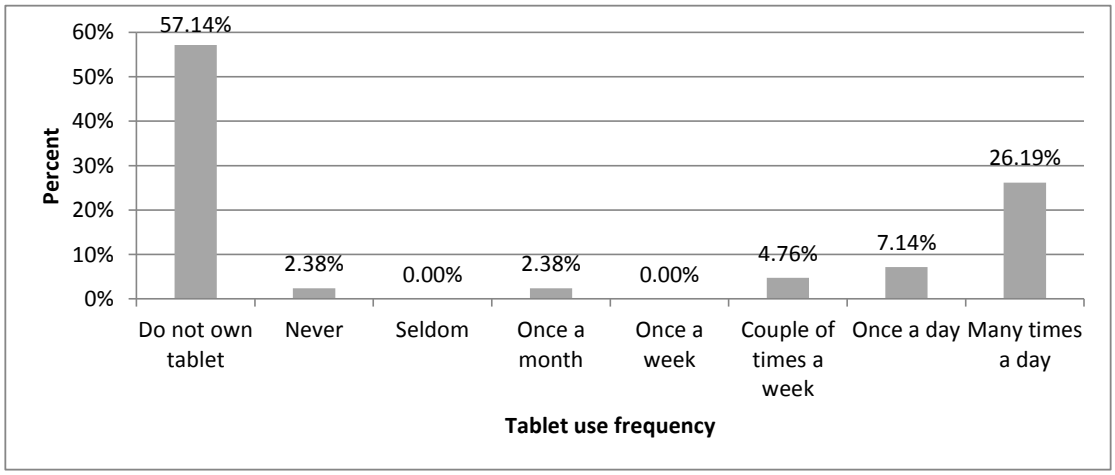


Figure 3.7: Tablet use frequency.

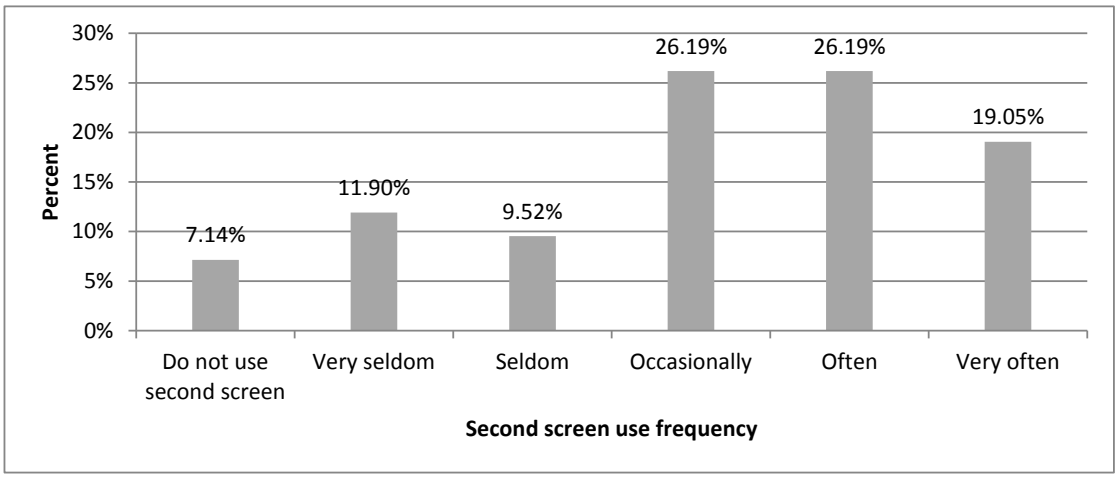


Figure 3.8: TV second screen use frequency.

TV channel and TV program sites were not as popular. Proulx and Shepatin [88, p. 88] also describes that people use websites such as Google, Wikipedia, and IMDb instead of visiting a TV network's site to find information about TV programs. It is worth to note that the popularity of web search engines can be explained by their function as a proxy to other information sources.

As most of the participants were young, had high education, were technologically oriented, and owned leading edge technology (in this case tablet), they could be profiled as early adopters of the diffusion of innovations theory [96, p. 283]. While the results of this study may not generalize to the majority of the popula-

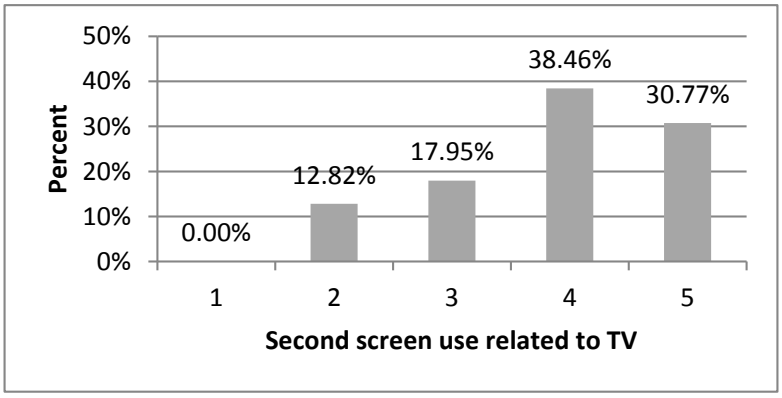


Figure 3.9: Degree to which the second screen usage is related to TV content. 1 = related to TV content, 5 = unrelated to TV content.

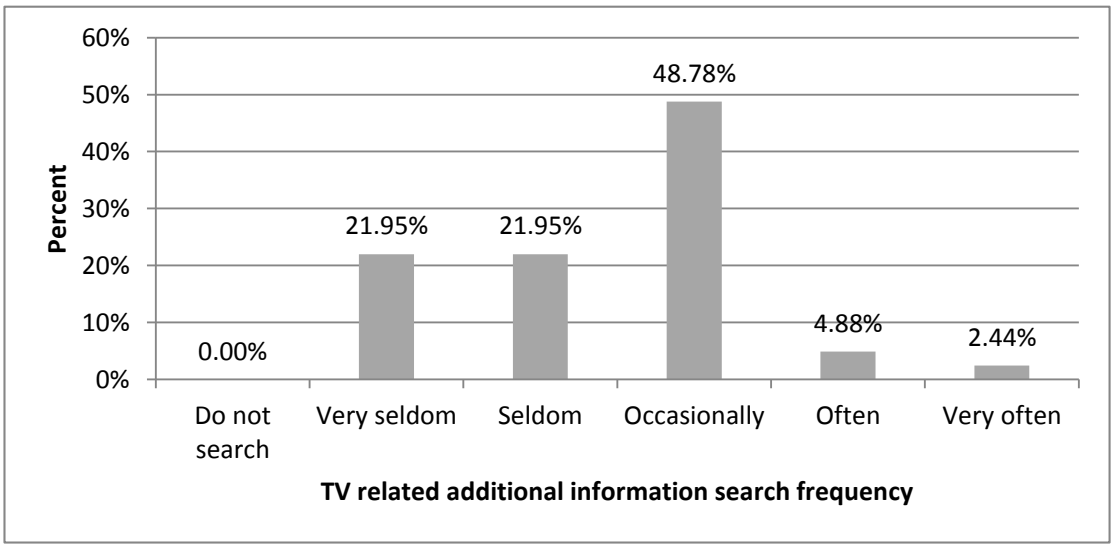


Figure 3.10: TV related information search frequency.

tion, the sample represented typical second screen users, and hence, was suitable for the experiment.

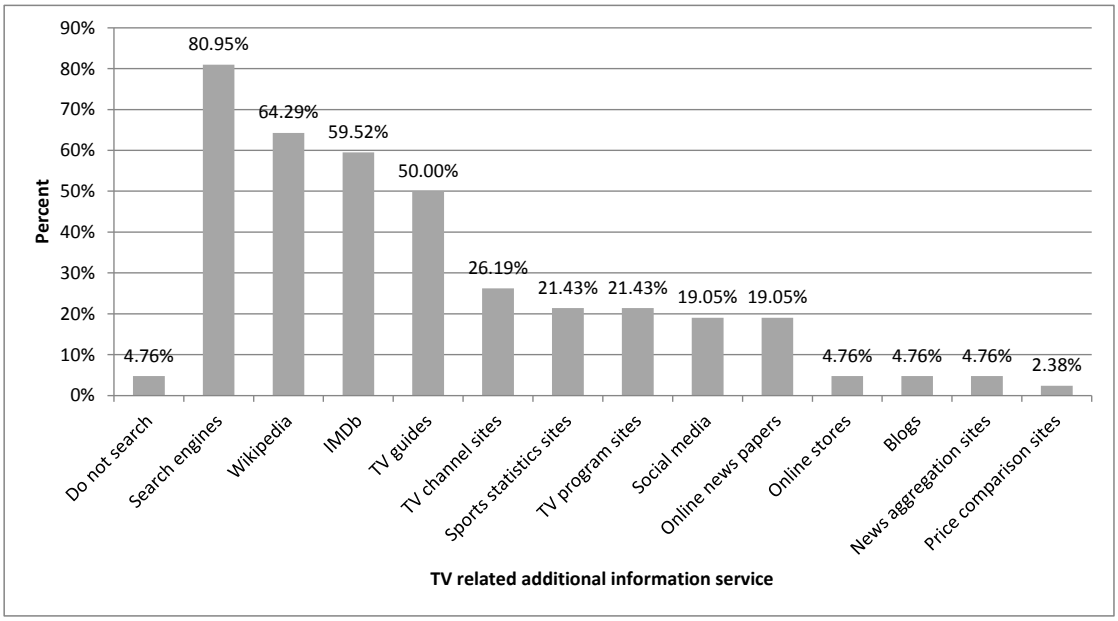


Figure 3.11: Services used to search for TV related information.

3.4 Apparatus

3.4.1 TV

The TV used to show the TV program stimuli was Sony Bravia KDL-40HX800 with a screen size of 40 inches and an aspect ratio of 1920 × 1080 pixels. The luminance of the screen was measured to be approximately 160 cd/m^2. The logo of the manufacturer below the screen was covered with black tape.

3.4.2 Tablet

Samsung Galaxy Tab 10.1 tablet was used as the second screen. The tablet had a screen size of 10.1 inches and an aspect ratio of 1280 × 800 pixels with 149 ppi resolution. The luminance of the tablet was measured to be approximately 130 cd/m^2. The tablet had Wi-Fi (also WLAN or wireless local area network) connectivity necessary for the experiment setup, and Mozilla Firefox web browser[3] for presenting the second screen web application. The front facing camera and the logo of the manufacturer on the bezel were covered with black tape.

[3]https://play.google.com/store/apps/details?id=org.mozilla.firefox

3.4.3 Physiological data recorder

The psychophysiological signals were recorded with Becker Meditec's VarioPort portable recording device. The device was used to record five channels including ECG, EDA and EMG on three facial muscle regions. All of the channels were recorded at 1000 Hz.

Modified lead-III placement of the Einthoven's triangle was used for the ECG electrodes. More specifically, the positive electrode was placed on the left 9th rib (the second lowest rib), the negative electrode below the left clavicle and the ground electrode on the right clavicle. The EDA electrodes were placed on the volar side of the non-dominant hand, on the medial phalanges of the index and little fingers. The recorded data was sent to a desktop computer via a Bluetooth connection and annotated with the experiment events (e.g. start/end of a trial) in real-time.

3.4.4 Eye tracker

SMI Eye Tracking Glasses (ETG)[4], a head-mounted eye tracking system, was used to track the gaze of the participants. As opposed to fixed eye trackers that have a limited tracking range and headbox [50, pp. 58-59], the ETG allowed the participants to move their head more freely, making the TV viewing more comfortable. More importantly, the ETG allowed tracking the gaze on multiple screens at differing distances. In the current experiment the ETG was calibrated to the TV screen[5].

The ETG tracked binocular eye movement at 30 Hz and captured scene video at 24 fps. Because the ETG lacked exposure adjustment, the TV and the tablet screens became overexposed in the scene video if the room was too dark compared to the screens. The overexposure was avoided by adjusting the room lighting and the brightness of the screens.

The eye tracking data was recorded on a laptop computer dedicated for the eye tracking recording. As the data streams of the psychophysiological and eye tracking data could not be combined online, the experiment events were associated with ETG timestamps during the experiment, and the two data streams were synchronized later with the help of experiment event annotations added to both streams.

[4]http://www.eyetracking-glasses.com/

[5]However, when tracking two screens at different distances, Holmqvist et al. [50, p. 133] suggest that the tracking accuracy can be improved by presenting some of the calibration points on one screen and some on the other screen.

3.4.5 Headphones

Sennheiser HD201[6] corded closed circumaural headphones were used to mitigate any distracting external noises and to improve the concentration of the participants. The headphones had a frequency response of 21–18000 Hz and a sound pressure level of 108dB at 1 kHz.

3.5 Stimuli

3.5.1 TV programs

The TV program stimuli were all in Finnish and they were approximately five minutes long video clips edited from video files provided by the Finnish Broadcasting Company Yleisradio[7]. Programs belonging to the genres magazine, documentary, reality, and sports (Table 3.1) were used as TV programs of these genres have been reported to be watched with a second screen [92, 112]. Common genres, such as drama and movies, were not included because their intense plot structure that requires continuous following [42], was assumed to be unsuitable for second screen use. The approximately five minute length was chosen to allow the participant to concentrate on the TV program shown and still have time to read additional information articles.

3.5.2 Tweets

Finnish tweets were collected by querying a batch of tweets with the name of TV program and then performing a query expansion [33] using hashtags (i.e. tags used to annotate tweets) found in the retrieved tweets. In case this procedure did not yield enough tweets, additional tweets were queried with terms associated with the TV program. Tweets that contained images or web links, or in which the message was unrelated to the TV program were excluded manually. The number of tweets shown with the TV programs ranged from 29 to 57 depending on the program.

3.5.3 Additional information

Finnish news articles from Yle News[8] website and Wikipedia[9] articles related to the TV programs were used as additional information content. The articles were

[6]http://en-de.sennheiser.com/over-ear-headphones-hd-201
[7]http://yle.fi/
[8]http://yle.fi/uutiset/
[9]http://fi.wikipedia.org/

collected by extracting search terms from the programs manually and querying articles on the Yle News and Wikipedia websites using the extracted terms. All annotations and external links were removed from the articles, and the articles were inspected not to contain information that was unavailable at the time of airing of the associated programs. The outlook of the article pages was transformed to be consistent using the Print Friendly[10] service. Each TV program was accompanied by 10 additional information articles. The presentation time of the articles was synchronized with the progress of the TV program (a common feature in second screen applications) as untimely second screen content may ruin the user experience [8].

3.6 Failed data recordings

Psychophysiological data of one participant could not be obtained due to failed recording. Eye tracking data of five participants had to be discarded due to failed recording, data corruption or poor quality of fixation detection[11]. Furthermore, prescription glasses prevented the use of the ETG with one participant (the ETG does not work reliably with prescription glasses). Sociodemographics data as well as the polychronicity index and the BIS/BAS indices of one participant were missing as the participant did not fill out the pre-experiment questionnaire form.

3.7 Environment

The experiment room was lit by two down facing and one up facing fluorescent lights. According to measurements the room illuminance was approximately 340 lux corresponding to normal office lighting. For environmental validity, the room could have been dimmer (i.e. 50 lux corresponding to a dimly lit living room) but the room had to be well lit as otherwise the TV and the tablet screens would have become overexposed in the scene video of the ETG (see Section 3.4.4).

The distance between the participant and the TV screen was approximately 225 cm conforming to the ITU recommendation [89]. The distance between the participant and the tablet was approximately 50 cm as the ETG required the target to be at least 40 cm apart from the wearer for the tracking to be accurate.

At times, noises could be heard from the corridor outside the experiment room. However, the participants reported that they did not notice any external noise as they were wearing headphones. In addition, a partitioning screen was placed

[10] http://www.printfriendly.com/

[11] However, the recordings can be considered relatively successful since as much as 20%-60% data losses has been reported in eye tracking studies [50, p. 141].

between the participant and the experimenter to prevent the presence of the experimenter from distracting the participant.

3.8 Software

Numerous commercial TV second screen tablet applications have been produced since 2010, after the introduction of the Apple iPad tablet [88, p. 89]. Consequently, most of these application have been implemented as native applications for the iPad. Examples include TV program specific applications such as ABC Grey's Anatomy Sync[12] and MLB At Bat[13], and second screen platforms such as Shazam[14] and IntoNow[15].

The emergence of HTML5 web technologies provided a feasible alternative to offer second screen applications as web applications instead of native applications. However, some requirements of the second screen applications (e.g. audio based automatic content recognition (ACR), a common technology to synchronize the second screen content with a TV program) and the constraints of HTML5, particularly the lack of smoothness and hardware support (e.g. support for accessing the device's microphone), have constrained the second screen applications to be native applications. However, recent advances in the HTML5 rendering, hardware support (including the microphone[16]) and real-time full-duplex communication protocols (e.g. WebSocket[17] and WebRTC[18]) have regained the parity with native applications for second screen application development.

The second screen application developed for the experiment in this thesis was implemented with HTML5. Particularly, the CSS animation and WebSocket communication features were utilized.

3.8.1 HTML5

HTML5 is an umbrella term for web technologies including HTML, CSS3 and JavaScript conforming to the HTML5 specifications[19]. HTML enables easy structuring of information and semantics and CSS3 is suitable for convenient experimentation and development of graphical user interfaces and animations. HTML5 applications are becoming feasible alternatives for native mobile applications as

[12] http://mashable.com/2011/02/01/greys-anatomy-ipad-app/
[13] http://mlb.mlb.com/mobile/atbat/
[14] http://www.shazam.com/
[15] http://www.intonow.com/
[16] http://www.w3.org/TR/mediacapture-streams/
[17] http://www.w3.org/TR/websockets/
[18] http://www.w3.org/TR/webrtc/
[19] http://www.w3.org/TR/html5/

it already provides rich features for graphical user interface construction and is also catching up in performance and hardware support [23]. Moreover, the development and deploying of HTML5 applications is considered to be cheaper than native applications as the same code can be applied on multiple platforms and the applications do not need to be installed.

3.8.2 WebSocket

WebSocket is a protocol in HTML5 that provides full-duplex web server–client communication over TCP [71]. While the initial handshake between the server and the client is done using HTTP, all communication thereafter is free from substantial header overhead of the HTTP protocol. The combined HTTP request and response overhead is over 400 times larger than the overhead of a WebSocket frame. The latency of HTTP polling is theoretically two times larger compared to the two-way communication of WebSocket. These properties make WebSocket an ideal technique for developing real-time web applications.

3.8.3 Architecture

A custom software system was built for running the experiment, presenting the stimuli, and synchronizing the recorded data from different sources. As Figure 3.12 presents, the system comprised of components responsible for presenting the TV programs (Video server), presenting the tablet contents (Second screen application), handling the collection of psychophysiological data (VarioPort server), and handling the collection of eye tracking data (ETG server). Experiment manager, the core of the system, managed communication between the components and orchestrated the operation of the whole system. Furthermore, Monitoring server and Control and monitoring client, which functioned as an interface for the Monitoring server, allowed real-time control and monitoring of the experiment. The components communicated via TCP connections, spanning from within-computer communications to wireless local area network (WLAN) mediated communications.

An Android-based[20] psychophysiological data recording framework developed by Meri [73] was used as a base to implement the VarioPort server. The framework would have allowed performing the psychophysiological recoding on the tablet, but due to reliability concerns with tablet based recording, the framework was ported to Standard Java[21] and run on a more capable desktop computer.

[20] http://www.android.com/

[21] http://www.oracle.com/technetwork/java/javase/overview/index.html

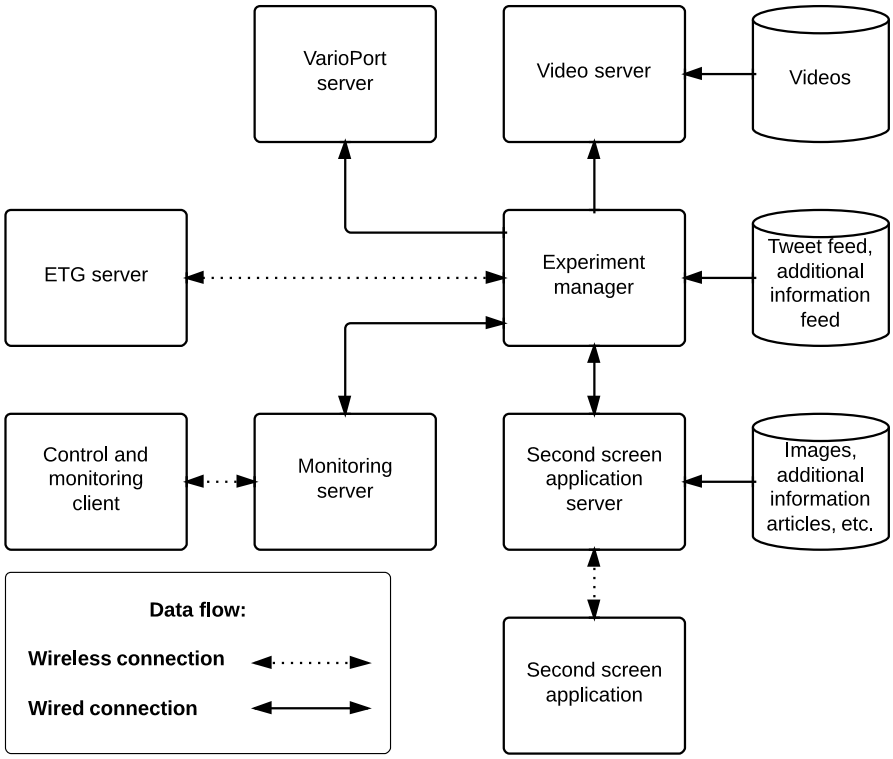


Figure 3.12: The architecture and data flow of the experiment system.

3.8.4 Graphical user interface

The graphical user interface (GUI) of the second screen application was designed according to the guidelines for mechanisms supporting multitasking Viitanen et al. [110].

Tweets and additional information content was presented on the tablet, inside three distinct GUI components (Figure 3.13). A feed component on the left presented tweets and another feed component on the right presented short descriptions of the additional information articles. The area in the middle between the two feeds was used to present the full additional information articles.

In Conditions, in which only either of the tweets or the additional information contents were presented, the GUI component was centered (Figure 3.14). When neither of the tablet contents were presented the tablet screen was blank.

The tweets feed items were composed of a profile image, Twitter name, full name, time elapsed since the tweet creation, the message, and a retweet button. The additional information feed items had a title, the first sentence of the full article as a short description of the article, an icon of Yle News or Wikipedia, and

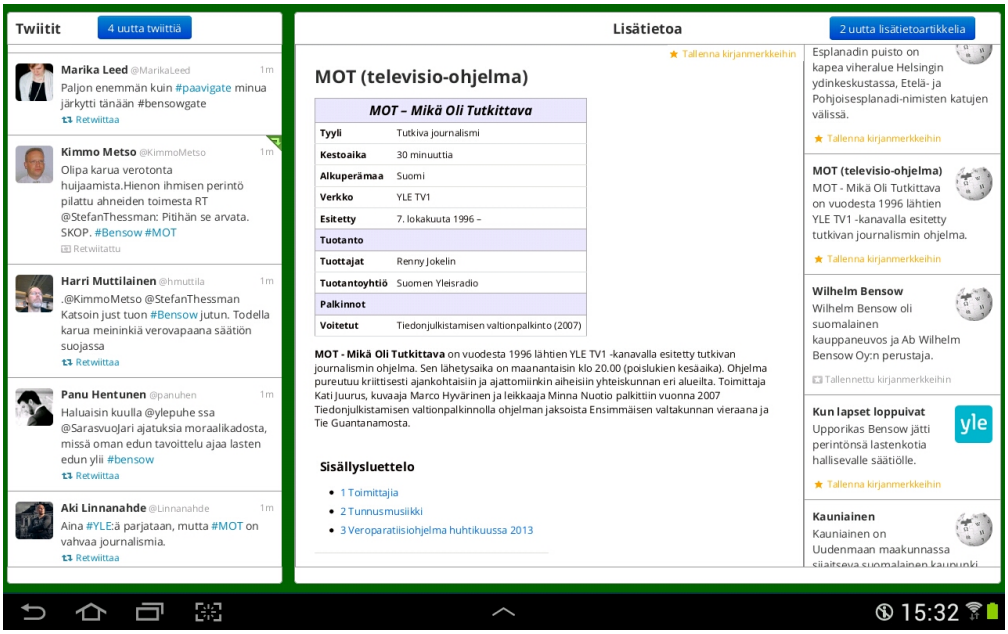
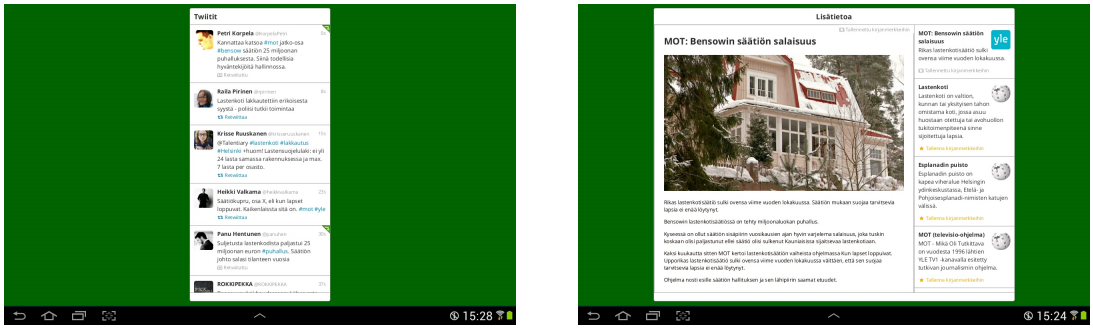


Figure 3.13: The GUI of the second screen application when both the tweets and the additional information were presented (Condition 4).



(a) Tweets only (b) Additional information only

Figure 3.14: The GUI of the second screen application when only the tweets (Condition 2) or only the additional information (Condition 3) was presented.

a bookmark button.

The full article was positioned to the left of the additional information feed, and could contain text, tables, images, and internal links. The full article also had a static bookmark button in the top right corner for convenience so that the participants did not need to look for the corresponding feed item in order to bookmark the article.

3.8.5 User interaction

Tweets and additional information items were arranged in feeds, in which new items were updated automatically and appeared at the top of the feed. For the updates to be noticeable with peripheral vision, they were emphasized with the following animations: a new item appeared by flashing once and the old items slided downwards to make space for the new item.

Older items could be revealed by scrolling down the feed. While the feed was not at the top position, the updates were not animated. Instead, the number of new items was indicated in a button in the feed header. By tapping the button, the feed scrolled automatically back to the top position, also restarting the update animation.

Tweets had a retweet button which the participants could tap to express that the tweet was interesting and worth sharing with others. The participants were not allowed to write their own tweets but the retweet button could be used to engage in active social interaction.

Likewise, additional information had a bookmark button which the participant could tap to express that the additional information was interesting and that they wanted to save it for later reading. Bookmarking allowed the participants to interact with additional information and it did not involve any social implication (as opposed to e.g. sharing an article). The participants could open and read the full articles by tapping the items in the additional information feed. The full articles, as such, could be scrolled and navigated with internal links.

Chapter 4

Preprocessing and analysis of data

The psychophysiological recordings, that is, the ECG (related to HR), EDA, and facial EMG data, have to be feature extracted in order to use them in statistical analysis. Appropriate frequency ranges have to extracted of the data to exclude noise. Furthermore, with regard to eye tracking, fixations that are extracted from the eye tracking data have to be annotated to estimate how much each area-of-interest was looked at. This chapter gives a detailed description of the signal processing procedures applied to each psychophysiological signal and the annotation of the eye tracking data. Furthermore, the used statistical analysis methods are specified.

4.1 ECG

In psychophysiological studies, only the reliable detection of the R-peaks on the ECG is usually required [55]. Followed by the detection of the R-peaks, series of R-R intervals are derived, and the duration of those intervals, namely, interbeat intervals (IBI) are calculated [90].

Ravaja [90] recommends using the respiratory sinus arrhythmia (RSA) to measure changes in attention. In order to calculate RSA, the IBI data should be free of artifacts as a single missed R-peak can bias the analysis results [12]. However, manual inspection of the data would have been a tedious process, and on the other hand, distribution-based artifact detection algorithms [10] would have been inadequate for the current purpose. Due to the aforementioned difficulties, IBI was selected for the analysis of ECG.

R-peaks were detected with the Augsburg Biosignal Toolbox (AuBT)[1] for Matlab[2]. Because calculating the mean of the raw IBI data in real time (as opposed to

[1] http://www.informatik.uni-augsburg.de/en/chairs/hcm/projects/tools/aubt/
[2] http://www.mathworks.se/products/matlab/

cardiac time) would be biased [11], the IBI data was time weighted by performing a zero-order hold interpolation. In order to reduce the effect of misdetected R-peaks (i.e. artifacts), values below 500 ms and above 1300 ms, being physiologically unnatural [2], were removed. Thereafter, values deviating more than three standard deviations from the participant mean were also removed. Finally, all removed data was replaced with a cubic interpolation.

4.2 EDA

The EDA signal was preprocessed and decomposed into tonic (SCL) and phasic (SCR) components using the Matlab-based Ledalab software developed by Benedek and Kaernbach [9]. EDA signal was downsampled to 10 Hz in order to reduce the amount of data, after which an adaptive smoothing filter was applied on it[3]. A threshold of 0.01 µS was used to detect SCRs. As no events (short-term stimuli) were associated with the SCRs, the SCRs were regarded as non-specific (NS-SCR). The number of NS-SCRs per minute was used as an index of tonic EDA (i.e. psychophysiological arousal).

4.3 EMG

As recommended by van Boxtel [109], the EMG signals were bandpass filtered within the frequency range of 20–500 Hz, which is the predominant frequency range of facial EMG signals. In particular, high-pass filtering at 20 Hz is required because of the various low-frequency movement artifacts [108]. Furthermore, a band-stop filter was applied at 50 Hz in order to remove the power line interference [109]. Some spikes at higher frequencies, presumably, higher harmonics of the power line frequency, were also distinguishable but they were negligible. Finally, the signal was rectified (absolute value of the signal was taken) and smoothed by lowpass filtering at 50 Hz. All filters were 3rd order Butterworth filters. Finally, as the probability distributions of the EMG values were positively skewed, as a common practice, logarithmic transformation was applied to the values to normalize the probability distributions [3].

[3]Prior to filtering, the data showed substantial amount of noise, perhaps, because of electrolytic wearing of the electrodes due to prolonged usage [17]

4.4 Eye tracking data

Eye tracking events (e.g. saccades, fixations) were detected using the SMI BeGaze 3.3 analysis software[4]. Annotation of the detected fixations into areas-of-interests, namely, the TV and the tablet screens, had to be done semi-automatically. The annotation process was assisted by clustering the fixation points spatially with K-means clustering [99]. Simple clustering proved to be a feasible method for annotation, as most of the fixation points that fell on the TV screen lied at the top, whereas most of the fixation points that fell on the tablet lied at the bottom, creating two distinct clusters. However, the clustering failed if the participant moved his/her head vertically while looking at the two screens. Hence, the automatically annotated clusters had to be confirmed manually.

The mean proportion of the total fixation duration to the total duration of all eye tracking events was 65.2% (SD = 6.5%), which is small compared to the observation by Irwin [54] that 90% of viewing time is usually devoted to fixations. A possible cause for this may be that the ETG, having a considerably low sampling rate, may have missed the shortest fixations. More probably, due to the two-screen setup that caused long saccades between the screens, the proportion of saccade duration grew abnormally large, consequently diminishing the proportion of fixation duration.

4.5 Statistical analysis

Linear Mixed Model (LMM) procedure available in IBM SPSS statistical analysis software[5] version 22.0 was used to perform the analysis. LMM is particularly useful as it has fewer restrictions, and it is more flexible than the traditional ANOVA or ANCOVA, with regards to the assumption of homogeneity and independence, unbalanced design and missing data [37, pp. 729–730].

TV programs, TWEETS, ADDINFO, trial order, polychronicity, and the two-way interactions between TV programs, TWEETS, and ADDINFO, were selected as fixed effects. TV programs, TWEETS, and ADDINFO were included in the model as they form the factors of the experiment design. Trial order was included as a covariate to take into account the effect of stimulus presentation order, and polychronicity was added as a continuous covariate to study its moderation effects.

For each psychophysiological measure, the respective baseline was added as a covariate in order to account for individual differences in psychophysiological

[4]http://www.smivision.com/en/gaze-and-eye-tracking-systems/products/begaze-analysis-software.html

[5]http://www.ibm.com/software/analytics/spss/

responses. The midmost one minute segment of the five minutes baseline measurement was used to calculate the baseline variables as the psychophysiological responses may not have stabilized at the beginning and the end of the measurement period. All baselines had a significant effect on the respective psychophysiological measure, as expected. Additionally, as movement is the primary cause of artifacts in EDA recording [17, p. 141], the total number of tablet interactions was added as a covariate for the EDA measure to mitigate the effect of participant movement.

Participant identifier was used as a contextual variable (level two variable), and trial order as a repeated effects variable. Compound symmetry was used as the repeated residual error covariance type. Significance was tested with 95% confidence interval, and restricted maximum likelihood was used as the fitting method. However, when comparing different models, the full maximum likelihood method was used because the model comparison requires this [37, pp. 737].

As a post-hoc test, pairwise comparisons were performed for the TV programs, TWEETS presence, ADDINFO presence and their two-way interactions. Confidence interval adjustment was not used, as the comparisons were considered to be independent.

Furthermore, in order to determine relationships between the dependent variables, Pearson correlations were calculated for them. As the number of cases was large, even very small correlations ended up to be significant, and thus, only the correlations with a large effect size (with correlation coefficients larger than 0.50 [24]) are discussed. That is, a correlation in this thesis refers to, not only a significant, but a large effect size correlation. Because of the large number of dependent variables, only notable correlations are reported.

Cronbach's alpha for the TV program related variables (Table 3.4) was $\alpha = .85$ (7 items), for the additional information related variables (Table 3.5) $\alpha = .91$ (10 items), and for the Multitasking Preference Inventory (MPI) items (Table B.3) $\alpha = .84$ (14 items), each indicating good reliability. Cronbach's alpha was not determined for other variable sets, as the items in them measured diverse phenomena.

Chapter 5

Results

This chapter presents the results of the experiment variable by variable. Thereafter, the results are discussed in more detail and linked to the research questions in Chapter 6. However, minor findings are discussed directly in this Chapter instead of Chapter 6.

5.1 Media experience

5.1.1 TV programs

As Table 5.1 shows, TV program relevance, likability, and concentration were correlated with each other. The table also shows that trustworthiness, novelty, and understandability did not correlate with any other TV program related media experience variable. Reasons for the weak correlations in these variables may lie in the differences in media experience variables between the programs. As Figure 5.1 shows, especially LOVE and DANCE, while scoring relatively well in most variables, lacked trustworthiness and novelty. All programs were evaluated to be equally understandable, except CAR which was significantly less understandable than the other programs.

As Table 5.2 shows, all TV program related media experience variables differed significantly between individual programs. Figure 5.1 presents the differences in all TV program related media experience variables between the programs. ORPHANAGE scored higher in interestingness compared to the other programs, and in contrast, NATURE and CAR were significantly less interesting than most of the other programs. While ORPHANAGE, MINE and LOVE were more relevant than the other programs, CAR was less relevant compared to the other programs. LOVE, CAR and DANCE were reported to be less trustworthy than the other programs. ORPHANAGE outperformed other programs in novelty, while LOVE,

Table 5.1: Correlations between TV program related media experience variables. Large effect size correlations (r > .50) are emphasized with gray color. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1.

	1.	2.	3.	4.	5.	6.
1. Interestingness	–					
2. Relevance	.80***	–				
3. Trustworthiness	.39***	.32***	–			
4. Novelty	.38***	.28***	.39***	–		
5. Understandability	.39***	.33***	.48***	.27***	–	
6. Likability	.88***	.75***	.37***	.34***	.44***	–
7. Concentration	.66***	.54***	.31***	.22***	.31***	.65***

CAR and DANCE offered less novel information compared to the other programs. Although all programs were evaluated as highly understandable, CAR differed from the other programs by being less understandable. ORPHANAGE had again higher likability than the other programs, and NATURE and CAR were liked less compared to most of the other programs. Participants concentrated less on NATURE and CAR compared to most of the other programs.

Table 5.2: The effect of TV programs on TV program related media experience variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Interestingness	(7, 271)	11.74	.00***
Relevance	(7, 271)	12.29	.00***
Trustworthiness	(7, 271)	15.55	.00***
Novelty	(7, 271)	22.21	.00***
Understandability	(7, 271)	6.80	.00***
Likability	(7, 271)	8.74	.00***
Concentration	(7, 271)	6.53	.00***

Interestingness variable in Figure 5.1 excellently summarizes the general pattern of differences in TV program related media experience variables between the programs. Apparently, ORPHANAGE outperformed the other programs in several TV program related media experience variables, and on the other hand, NATURE and CAR seemed to score less in most TV program related media experience variables compared to the other programs.

As for the effect of ADDINFO on media experience of TV programs, table 5.3 indicates that ADDINFO did not have any effect on TV program related media

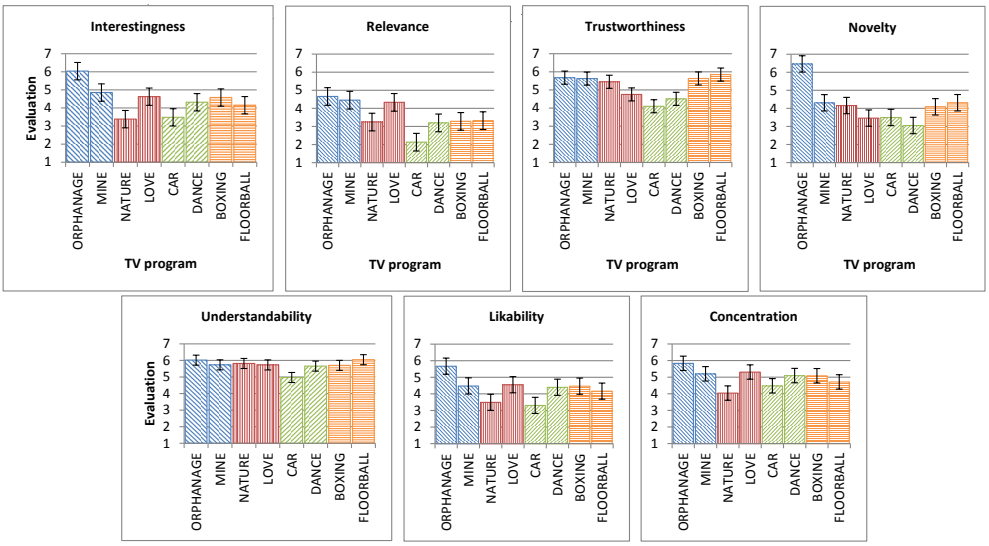


Figure 5.1: TV program related media experience variable means with 95% CIs for the programs. The colors/patterns, which are used throughout this thesis, differentiate the genres listed in Table 3.1.

experience variables, except concentration. Not surprisingly, concentration was significantly reduced by ADDINFO. ADDINFO had an almost significant effect on novelty, which may hint that the participants confused that they obtained novel information from the TV program, although in reality the information was brought by the articles.

Table 5.3: The effect of ADDINFO on TV program related media experience variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Interestingness	(1, 271)	.44	.51
Relevance	(1, 271)	.04	.85
Trustworthiness	(1, 271)	.31	.58
Novelty	(1, 271)	3.17	.08†
Understandability	(1, 271)	1.83	.18
Likability	(1, 271)	.14	.71
Concentration	(1, 271)	24.56	.00***

As Figure 5.2 reveals, ADDINFO reduced concentration on the TV program significantly for ORPHANAGE, LOVE, and CAR, and almost significantly for BOXING. However, the effect was clearly present for all of the programs. Novelty

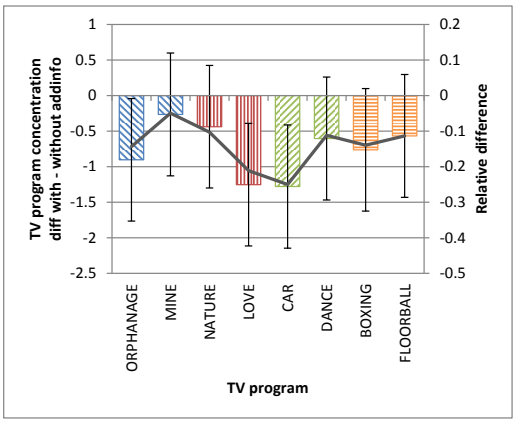


Figure 5.2: Mean difference of TV program concentration with 95% CIs between conditions with - without ADDINFO for the programs. The gray line shows the relative difference.

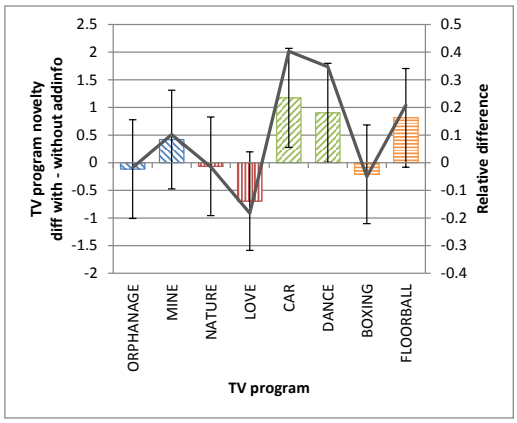


Figure 5.3: Mean difference of TV program novelty with 95% CIs between conditions with - without ADDINFO for the programs. The gray line shows the relative difference.

of the program, in turn, was increased by ADDINFO significantly for CAR and DANCE, and also marginally for FLOORBALL, as Figure 5.3 shows.

5.1.2 Additional information

As Table 5.4 indicates, most of the additional information related media experience variables were correlated with each other, except trustworthiness and relatedness because the articles were collected from relatively trustworthy sources (as opposed to e.g. yellow journalism) and they were also highly related to the programs. Understandability was correlated only with novelty because, as Figure 5.4 shows, there was very little variation in understandability of additional information between the programs.

Table 5.4: Correlations between additional information related media experience variables. Large effect size correlations (r > .50) are emphasized with gray color. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1.

	1.	2.	3.	4.	5.	6.	7.	8.	9.
1. Interestingness	–								
2. Relevance	.77***	–							
3. Trustworthiness	.37***	.33***	–						
4. Novelty	.60***	.53***	.31***	–					
5. Understandability	.36***	.20**	.37***	.52***	–				
6. Likability	.75***	.74***	.37***	.66***	.38***	–			
7. Concentration	.54***	.57***	.33***	.54***	.29***	.58***	–		
8. Valuableness	.60***	.62***	.34***	.60***	.42***	.70***	.68***	–	
9. Experience enhancement	.54***	.58***	.34***	.53***	.38***	.66***	.63***	.86***	–
10. Relatedness	.44***	.31***	.32***	.44***	.37***	.39***	.31***	.33***	.26**

Table 5.5 makes it evident that there were significant differences between the programs as they influenced the interestingness, trustworthiness, likability, and relatedness of additional information, and also had marginal effects on relevance and novelty. The many significant effects and almost significant effects confirm that TV programs had an effect on the media experience of additional information, and differences between programs are expected.

Table 5.5: The effect of TV programs on additional information related media experience variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Interestingness	(7, 112)	2.60	.02*
Relevance	(7, 110)	1.95	.07†
Trustworthiness	(7, 112)	2.71	.01*
Novelty	(7, 111)	1.86	.08†
Understandability	(7, 105)	.99	.44
Likability	(7, 107)	3.78	.00**
Concentration	(7, 104)	1.51	.17
Valuableness	(7, 107)	1.22	.30
Experience enhancement	(7, 110)	.54	.80
Relatedness	(7, 110)	3.29	.00**

Results of the post-hoc tests, plotted in Figure 5.4, reveal that additional information accompanied with ORPHANAGE, MINE, and BOXING was more interesting than that accompanied with the other programs. The same held also in relevance, trustworthiness, likability. As for novelty, mainly BOXING scored higher than NATURE, LOVE, and DANCE. Articles in the case of CAR and DANCE were considered to be less related to the TV program than for the other programs.

There were generalizable differences in additional information related media experience variables between the programs. In general, additional information related media experience variables scored higher for magazine and sports programs, particularly for ORPHANAGE, MINE, and BOXING. An apparent deviation from this pattern was CAR, for which the score was on par with the score of magazine and sports programs with respect to novelty, likability, and concentration, as can be seen in Figure 5.4. In other words, media experience of additional information was relatively high for CAR. However, media experience of CAR program, as such, was relatively poor. This relationship is illustrated by Figure 5.5, which plots likability of additional information against likability of the programs. Similar to CAR, TV program likability of NATURE was low but, unlike CAR, additional information

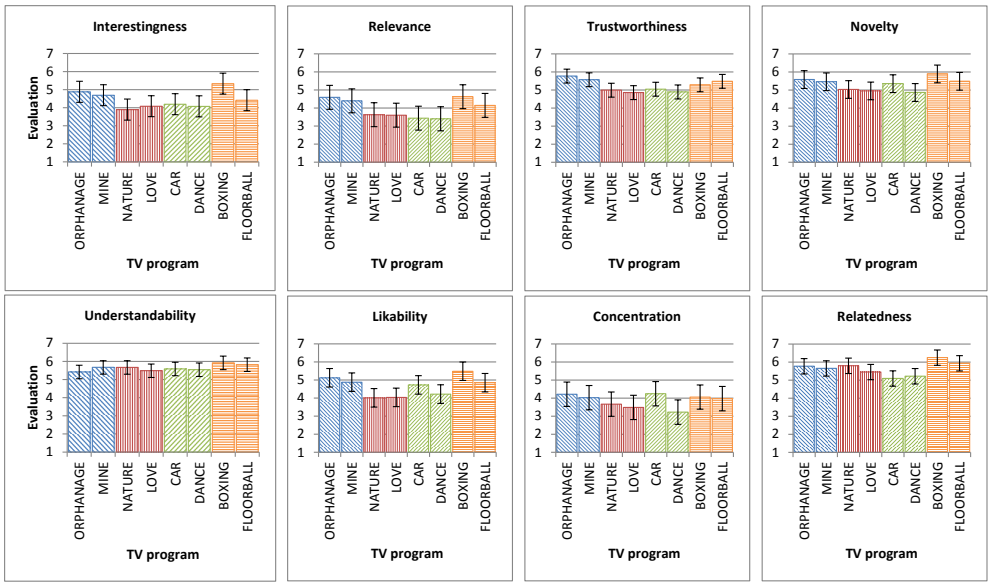


Figure 5.4: Additional information related media experience variable means with 95% CIs for the programs.

likability for NATURE was low as well. One possible reason for this incongruity may be that, as Figure 5.1 shows, the understandability of CAR was significantly lower compared to the other programs.

Table 5.6 shows that TWEETS had a significant effect on several additional information related media experience variables including novelty, understandability, concentration, valuableness, and relatedness. TWEETS also had a marginal effect on experience enhancement.

Figure 5.6 strongly indicates that the aforementioned effect of TWEETS on additional information related media experience variables was negative in nature. Although not significantly, TWEETS clearly weakened the evaluation of the other additional information related media experience variables as well.

Furthermore, as Table 5.7 shows, polychronicity predicted additional information novelty, likability, and experience enhancement, and marginally predicted interestingness, relevance, and valuableness. The finding suggests that there is a positive relationship between polychronicity and perceived media experience of additional information.

5.1.3 Multitasking

Correlations found between multitasking related variables can be argued to be consistent. Table 5.8 shows that multitasking effort (see Table 3.6) was correlated with the "tablet distracts TV" variable as, in practice, the presence of the tablet

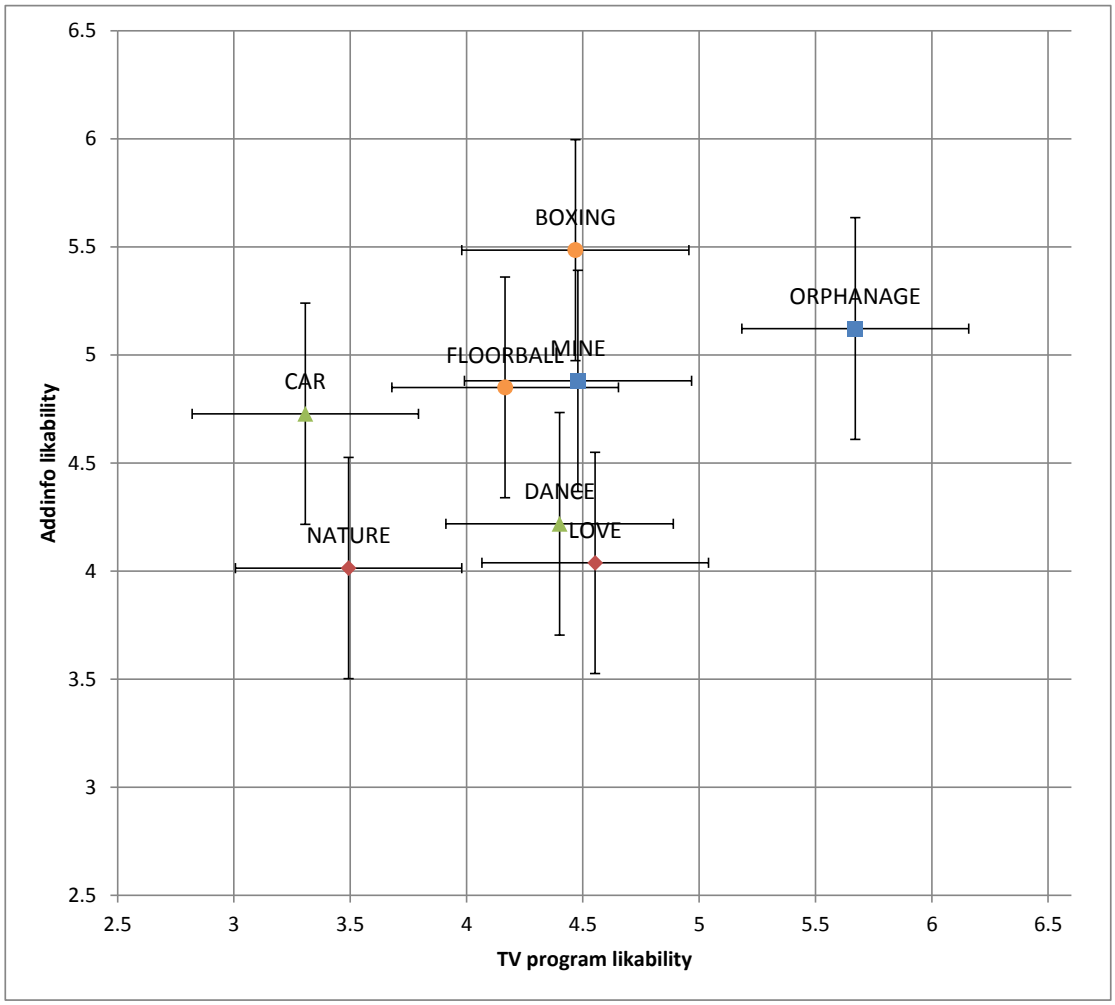


Figure 5.5: Additional information likability and TV program likability means with 95% CIs for the programs.

created the multitasking environment. The self-reported TV–tablet attention distribution was correlated with the "main screen" variable, suggesting that the more attention was paid on the tablet the more likely it was the main screen.

Table 5.9 shows that the willingness of the participants to search for additional information about the TV program and the self-reported tweets–additional attention distribution differed significantly between the programs. In addition, the main screen variable differed marginally between the programs.

Figure 5.7 shows that search willingness was higher for both magazine programs and BOXING compared to the rest of the programs. The result resembles the general pattern observed in the differences in additional information related media

Table 5.6: The effect of TWEETS on additional information related media experience variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Interestingness	(1, 113)	1.56	.21
Relevance	(1, 113)	1.62	.21
Trustworthiness	(1, 112)	.28	.60
Novelty	(1, 113)	9.59	.00**
Understandability	(1, 113)	6.00	.02*
Likability	(1, 113)	.89	.35
Concentration	(1, 113)	10.69	.00**
Valuableness	(1, 113)	5.12	.01*
Experience enhancement	(1, 113)	3.90	.05†
Relatedness	(1, 113)	12.07	.00**

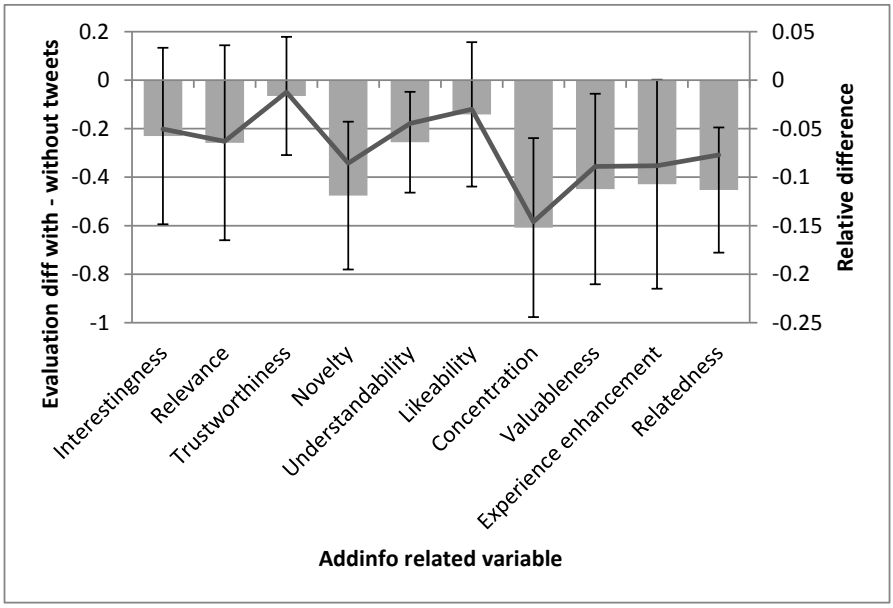


Figure 5.6: Mean difference of additional information related media experience variables with 95% CIs between conditions with - without TWEETS. The gray line shows the relative difference.

experience variables between the programs. However, search willingness and for example additional information interestingness were not correlated with large effect size ($r = .35, p < .001$). Figure 5.8, in turn, shows that NATURE stood out

Table 5.7: The effect of polychronicity on additional information related media experience variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Interestingness	(1, 37)	3.47	.07†
Relevance	(1, 37)	3.96	.05†
Trustworthiness	(1, 36)	.01	.91
Novelty	(1, 38)	7.31	.01*
Understandability	(1, 37)	.21	.65
Likability	(1, 37)	5.95	.02*
Concentration	(1, 37)	.73	.40
Valuableness	(1, 37)	3.43	.07†
Experience enhancement	(1, 38)	5.46	.03*
Relatedness	(1, 38)	.13	.73

Table 5.8: Correlations between multitasking related variables. Large effect size correlations (r > .50) are emphasized with gray color. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1.

	1.	2.	3.	4.	5.	6.
1. Search willingness	–					
2. Multitasking effort	.17**	–				
3. TV-tablet attention	.17**	.15*	–			
4. Tweets-addinfo attention	.28**	-0.01	-0.04	–		
5. Tablet distracts TV	-0.06	.52***	-.14*	-0.08	–	
6. TV distracts tablet	.16**	.29***	.25***	0.07	.19**	–
7. Main screen	-0.06	-0.07	.52***	-0.04	-0.12†	.19**

Table 5.9: The effect of TV programs on multitasking related variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Search willingness	(7, 270)	10.76	.00***
Multitasking effort	(7, 168)	1.42	.20
TV–tablet attention	(7, 174)	1.17	.32
Tweets–addinfo attention	(7, 41)	2.63	.02*
Tablet distracts TV	(7, 154)	0.95	.47
TV distracts tablet	(7, 159)	0.20	.99
Main screen	(7, 193)	2.04	.05†

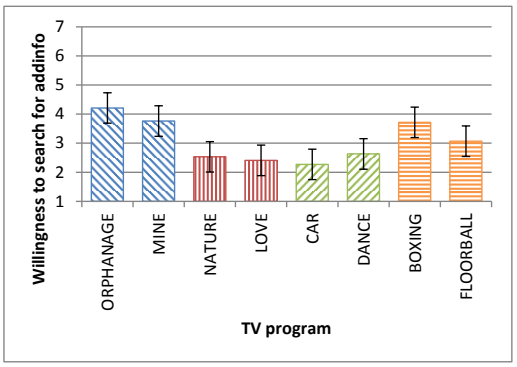


Figure 5.7: The search willingness variable with 95% CIs for the programs.

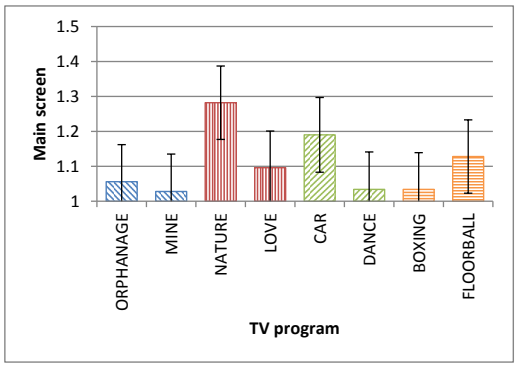


Figure 5.8: The main screen variable with 95% CIs for the programs. 1 = TV, 2 = tablet.

by scoring higher in the main screen variable than the other programs. With the exception of ORPHANAGE, LOVE, and FLOORBALL, which did not differ significantly from CAR, the main screen score for CAR was also higher compared to the other programs. The pattern bear a close inverse resemblance to the pattern in the TV program related media experience variables, which indicated that the media experience was poor for NATURE and CAR. Indeed, Pearson correlation between interestingness of the programs and the main screen variable was r = -.57 ($p < .001$), indicating large effect size negative correlation between the variables.

However, as the mean scores in Figure 5.8 are close to 1 for most of the TV programs, it is clear that the TV had a firm position as the main screen, and the tablet became the main screen on rare occasions.

Table 5.10 shows that, ADDINFO, as such, did not affect search willingness, confirming that the presented additional information did not bias the responses (no other dependent variable had an effect either). ADDINFO predicted multitasking effort and self-reported attention distribution on the tablet. Interestingly, ADDINFO was not found to be distracting TV viewing but, on the contrary, TV was distracting tablet use when ADDINFO was presented. Moreover, ADDINFO predicted whether the tablet was considered to be the main screen.

As Figure 5.11 presents, polychronicity also predicted self-reported attention distribution on the tablet, and marginally predicted whether the tablet was considered to be the main screen.

Table 5.10: The effect of ADDINFO on multitasking related variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Search willingness	(1, 270)	1.327	.25
Multitasking effort	(1, 188)	3.971	.05*
TV–tablet attention	(1, 188)	9.725	.00**
Tablet distracts TV	(1, 188)	.375	.54
TV distracts tablet	(1, 188)	12.649	.00**
Main screen	(1, 188)	4.575	.03*

Table 5.11: The effect of polychronicity on multitasking related variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Search willingness	(1, 39)	.51	.48
Multitasking effort	(1, 37)	.95	.34
TV–tablet attention	(1, 37)	4.42	.04*
Tweets–addinfo attention	(1, 38)	.29	.60
Tablet distracts TV	(1, 37)	1.32	.26
TV distracts tablet	(1, 37)	1.94	.17
Main screen	(1, 37)	3.47	.07†

5.2 Additional information interaction

As Table 5.12 shows, the number of opened articles and the number of uniquely opened articles were correlated. This is a trivial result as the number of uniquely opened articles is a subset of the number of opened articles.

Table 5.12: Correlations between additional information related interaction variables. Large effect size correlations (r > .50) are emphasized with gray color. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1.

	1.	2.	3.
1. Opened articles	–		
2. Uniquely opened articles	.92***	–	
3. Bookmarked articles	.32***	.28***	–
4. Feed interactions	.32***	.22**	0.11

Table 5.13 indicates that there were no differences in the number of additional information related interactions between the programs. This result may imply that there TV programs do not affect how additional information is actually used on second screen.

Table 5.13: The effect of TV programs on additional information related interaction variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Opened articles	(7, 102)	.23	.98
Uniquely opened articles	(7, 96)	.16	.99
Bookmarked articles	(7, 108)	1.68	.12
Feed interactions	(7, 111)	1.53	.16

Likewise with additional information related media experience variables, TWEETS had a deteriorating effect on the number of additional information related interactions, as illustrated in Figure 5.9. Table 5.14 shows that TWEETS had a significant inhibiting effect on the number of opened articles, the number of uniquely opened articles, and the number of additional information feed interactions. Notably, TWEETS did not have an effect on the number of bookmarked articles.

Table 5.14: The effect of TWEETS on additional information related interaction variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Opened articles	(1, 110)	20.83	.00***
Uniquely opened articles	(1, 110)	26.76	.00***
Bookmarked articles	(1, 110)	1.42	.24
Feed interactions	(1, 110)	4.72	.03*

As Table 5.15 presents, Polychronicity predicted the number of bookmarked articles, and marginally predicted the number of opened articles and the number of uniquely opened articles. As polycronicity also affected several additional information related media experience variables, the current result may indicate that media experience of additional information is associated with how much there is interaction with additional information.

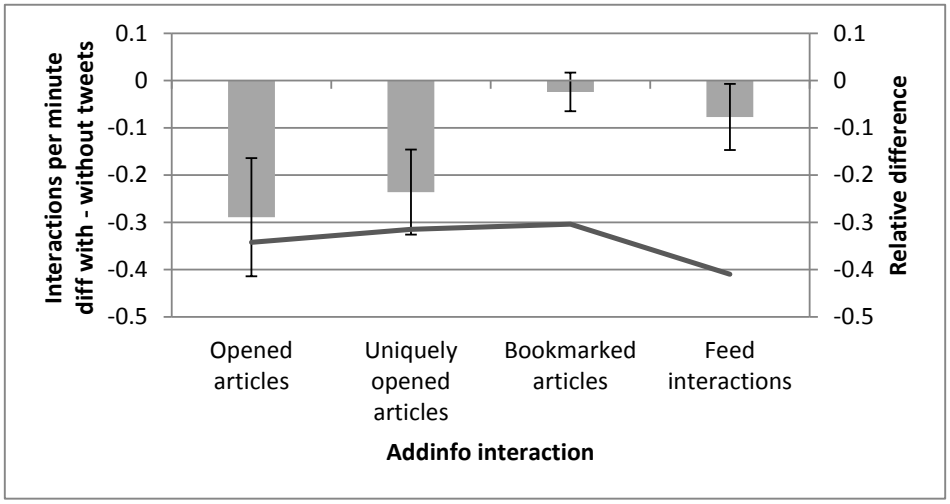


Figure 5.9: Mean difference of additional information related interaction variables with 95% CIs between conditions with - without TWEETS. The values are interactions per minute. The gray line shows the relative difference.

Table 5.15: The effect of polychronicity on additional information related interaction variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
Opened articles	(1, 36)	3.34	.08†
Uniquely opened articles	(1, 36)	3.13	.09†
Bookmarked articles	(1, 36)	6.40	.02*
Feed interactions	(1, 37)	.27	.61

5.3 Attention

5.3.1 Visual attention

As described in Section 3.1.2, visual attention was measured objectively using eye tracking and calculating the proportion of total fixation duration on the tablet from the eye tracking data.

The proportion of total fixation duration on the tablet was correlated with the self-reported attention distribution between the TV and the tablet ($r = .64$). Laine-Hernandez et al. [63] also found a correlation between measured visual attention and self-reported visual attention. The finding is useful as it implies that visual attention distribution between two screens can be measured reliably by

self-reports.

Figure 5.10 shows that ADDINFO predicted the visual attention on the tablet ($F(1, 187) = 9.45, p < .01$). According to post-hoc tests the effect was significant in all programs except NATURE and DANCE.

Furthermore, a marginal interaction effect could be observed between ADDINFO and TWEETS ($F(1, 187) = 3.02, p = .08$). Figure 5.11 reveals that the participants fixated on the tablet more when only ADDINFO was presented compared to when only TWEETS were presented because reading articles rich in content requires more visual attention than does reading short tweets. Consistently, visual attention on the tablet was highest when both TWEETS and ADDINFO were presented.

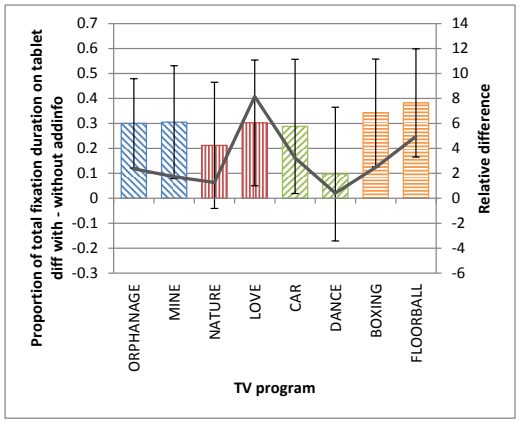


Figure 5.10: Mean difference of proportion of total fixation duration on tablet with 95% CIs between conditions with - without ADDINFO for the programs. The gray line shows the relative difference.

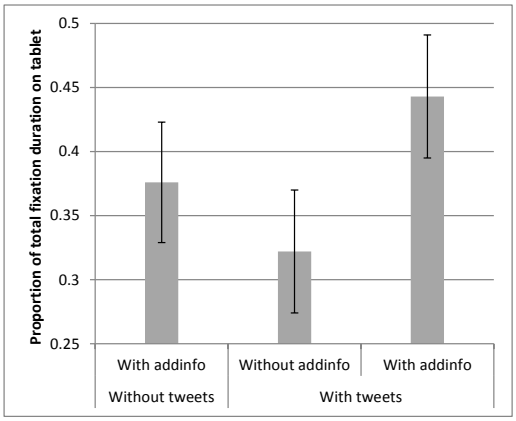


Figure 5.11: Proportion of total fixation duration on tablet with 95% CIs for different ADDINFO and TWEETS combinations. The variable was not calculated for the condition in which neither TWEETS nor ADDINFO was presented.

Polychronicity predicted the proportion of total fixation duration on the tablet ($F(1, 31) = 6.25, p < .05$) suggesting that more polychronous participants looked more at the tablet. The result is in accordance with the effect of polychronicity on self-reported attention distribution on tablet.

5.3.2 Heart rate

The mean of weighted IBI was calculated from HR and used as a psychophysiological index of attention. There was a significant difference in IBI between the

programs ($F(7, 263) = 7.31, p < .001$). However, as Figure 5.12 shows, IBI was significantly smaller when viewing sports programs (i.e. HR is higher) compared to the rest of the programs. The result can be interpreted that IBI was not measuring attention but it was rather measuring emotional arousal (see Section 2.7.1). However, because of the dual innervation of the heart, HR is not a very good index of emotional arousal either [82].

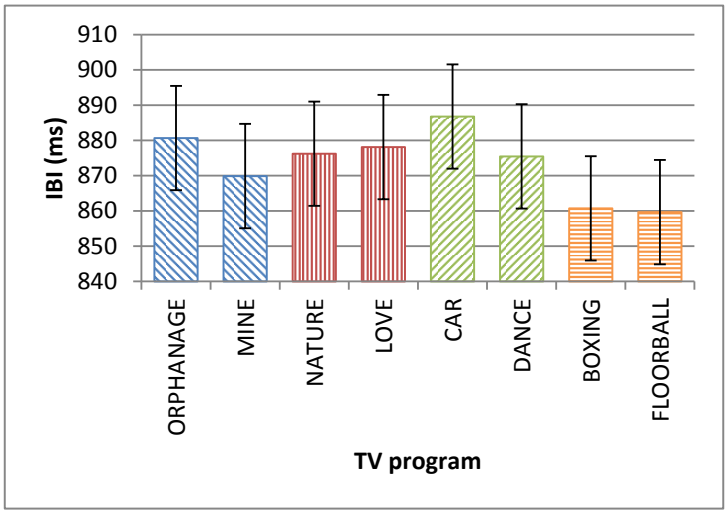


Figure 5.12: IBI with 95% CIs for the programs over all conditions.

5.4 Emotion

5.4.1 Self-reported valence and arousal

Self-reported valence and arousal measured the combined affective experience of both TV and tablet contents. Obviously, the valence and arousal were measured only of the TV program when no tablet content was presented.

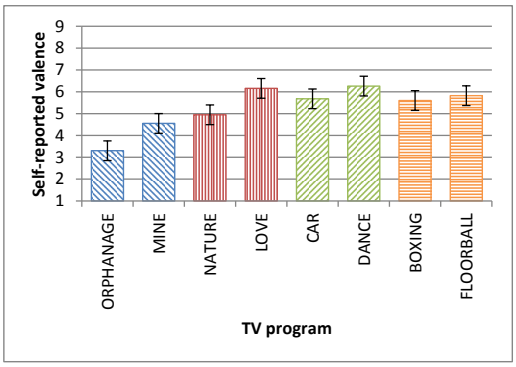
Table 5.16 shows that while self-reported valence did not correlate with the other dependent variables, self-reported arousal did correlate with interestingness, relevance, and likability of the TV programs. This result is in line with the well known fact that arousal is associated with liking of messages [67].

As Figure 5.13 indicates, self-reported valence and arousal significantly differed between the TV programs. ORPHANAGE and MINE were evaluated to be more negative than the other programs because of their critical tone (for details, see Table A.1). Also NATURE, which depicted an environmental issue with the barnacle goose, was also evaluated more negative than most of the other programs.

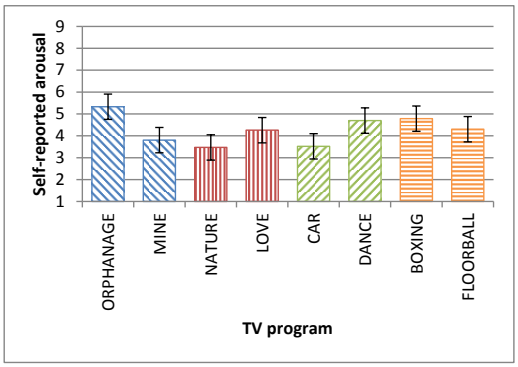
Table 5.16: Correlations of self-reported valence and arousal to TV program related media experience variables. Large effect size correlations (r > .50) are emphasized with gray color. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1.

	1.	2.
1. Self-reported valence	–	
2. Self-reported arousal	.11*	–
Interestingness	.24***	.56***
Relevance	.18**	.56***
Trustworthiness	0.06	.16**
Novelty	-.14**	.18**
Understandability	0.10†	.15**
Likability	.31***	.51***
Concentration	.23***	.45***

ORPHANAGE was reported to be more arousing than the other programs except BOXING which did not differ significantly from ORPHANAGE.



(a) Valence. 1 = very negative, 9 = very positive.



(b) Arousal. 1 = weakly arousing, 9 = strongly arousing.

Figure 5.13: Self-reported valence and arousal with 95% CIs for the programs over all conditions.

ADDINFO did not have any effect on self-reported valence ($F(1, 271) = .12, p = .73$) or arousal ($F(1, 270) = 1.66, p = .12$). Apparently, the combined affective experience of TV programs and additional information was dominated by the affective experience of the TV programs.

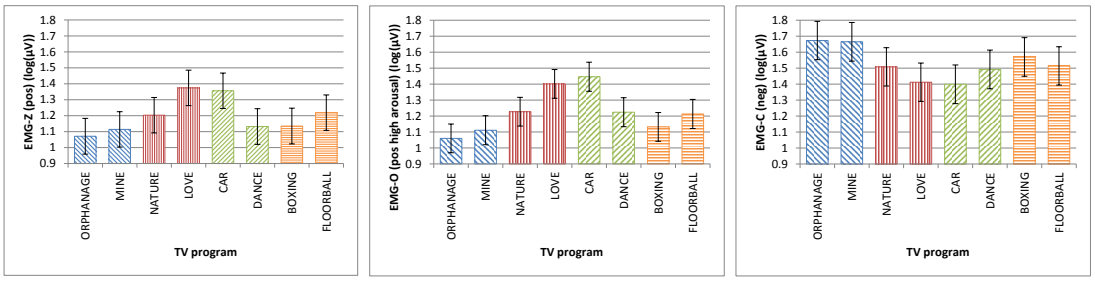
5.4.2 Psychophysiological valence and arousal

The mean of facial EMG responses, namely, EMG-Z (positive valence) and EMG-O (high arousal positive valence), and EMG-C (negative valence) were used to measure psychophysiological valence.

As Table 5.17 shows, all EMGs differed significantly between the TV programs. Figure 5.14 shows that LOVE and CAR elicited larger EMG-Z (positive valence) and EMG-O (high arousal positive valence) responses compared to the other programs. Together with the fact that both of these programs had a humorous tone, the close resemblance of responses with respect to these two variables for different programs confirm that the variables are valid as a measure of positive valence. On the contrary, EMG-C (negative valence) response was larger for ORPHANAGE and MINE than for the other programs, except BOXING which did not differ significantly from the aforementioned programs. As ORPHANAGE and MINE both dealt with negative topics, EMG-C was apparently measuring negative valence.

Table 5.17: The effect of TV programs on psychophysiological valence and arousal variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	df	F	p
EMG-Z (pos)	(7, 263)	8.40	.00***
EMG-O (pos high arousal)	(7, 263)	14.75	.00***
EMG-C (neg)	(7, 263)	6.91	.00***
NS-SCR (arousal)	(7, 262)	4.49	.00***



(a) EMG-Z (positive). (b) EMG-O (positive high arousal). (c) EMG-C (negative).

Figure 5.14: Facial EMGs with 95% CIs for the programs.

As Table 5.18 indicates, ADDINFO had an effect on EMG-O (high arousal positive valence) but not on EMG-Z or EMG-C. Figure 5.15 further reveals that, in general, ADDINFO had a decreasing effect on EMG-O (high arousal positive

valence). The finding may imply that ADDINFO impaired enjoyability of the TV programs despite the fact that ADDINFO did not affect the TV program related media experience variables (apart from reducing concentration). However, it is worth to note that the effect was significant only for CAR.

Table 5.18: The effect of ADDINFO on psychophysiological valence and arousal variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
EMG-Z (pos)	(1, 263)	1.42	.23
EMG-O (pos high arousal)	(1, 263)	9.44	.00**
EMG-C (neg)	(1, 263)	2.16	.14
NS-SCR (arousal)	(1, 267)	4.06	.05*

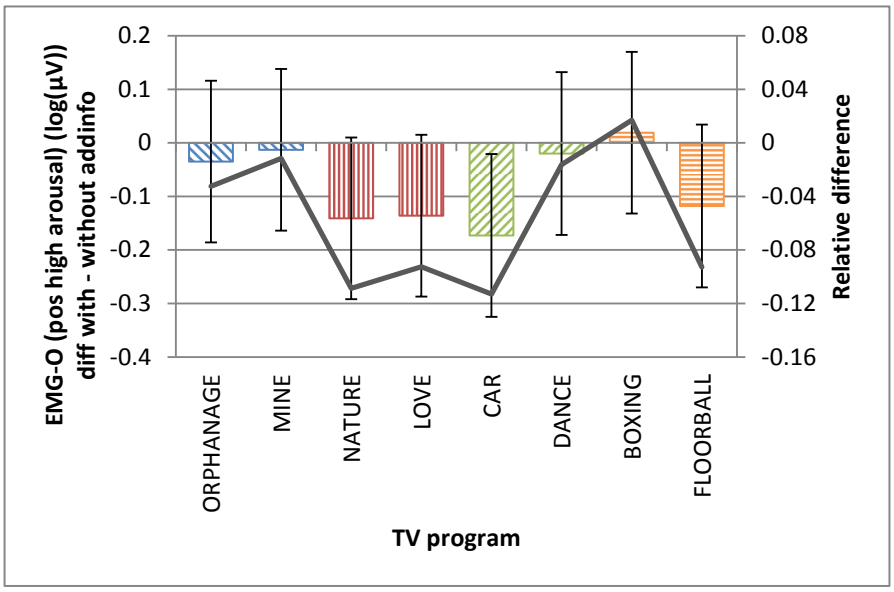


Figure 5.15: Mean difference of EMG-O (positive high arousal) with 95% CIs between conditions with - without ADDINFO for the programs. The gray line shows the relative difference.

Table 5.19 shows that polychronicity predicted EMG-O (high arousal positive valence), that is, more polychronous participants had larger positive valence response.

The number of NS-SCRs per minute, a measure of tonic EDA, was used as an index of psychophysiological arousal. Table 5.17 shows that there were significant

Table 5.19: The effect of polychronicity on psychophysiological valence and arousal variables. ***p < 0.001, **p < 0.01, *p < 0.05, †p < 0.1. Degrees of freedom (df) are rounded values.

Variable	**df**	**F**	**p**
EMG-Z (pos)	(1, 37)	2.70	.11
EMG-O (pos high arousal)	(1, 37)	6.52	.02*
EMG-C (neg)	(1, 37)	.42	.52
NS-SCR (arousal)	(1, 37)	2.65	.11

differences in the number of NS-SCRs between the TV programs.

As Figure 5.16 shows, LOVE was the most arousing, significantly more so than ORPHANAGE, MINE, NATURE, and CAR. DANCE was also more arousing than MINE, NATURE, and CAR. On the contrary, NATURE was the least arousing, being significantly less arousing than LOVE, DANCE, BOXING, and FLOORBALL. According to Zillmann [116], hilarious TV programs (e.g. LOVE), violence (e.g. BOXING) and televised athletic contests (e.g. DANCE, BOXING and FLOORBALL) elevate arousal levels substantially. Furthermore, erotic films consistently produce the strongest excitatory reactions in both men and women. Although not explicit erotica, LOVE may have had some subtle erotic connotation. In contrast, a stereotypical nature film (e.g. NATURE), not only lacks the capacity to arouse, but actually lower the level of arousal.

Table 5.18 indicates that ADDINFO predicted psychophysiological arousal. Figure 5.17 further shows that ADDINFO generally increased arousal, which may be a sign of cognitive load caused by multitasking, but the effect was not significant for any of the TV programs.

5.5 Post-experiment comments

Open-ended comments about general experience of using the second screen application were collected in a post-experiment questionnaire as explained in Section 3.2. Overall, the application was considered to be simple and easy to use and brought additional value to TV viewing.

Nevertheless, many drawbacks were also reported. Many participants were distracted by the flashing animation associated with tablet content updates. Employing other modalities such as vibration or sound were suggested by some participants. Yet, some participants particularly liked the silent operation of the application. The distractive feeling may have been intensified, when the flashing animation draw attention in inappropriate occasions as untimely second screen content reportedly has averse effects [74].

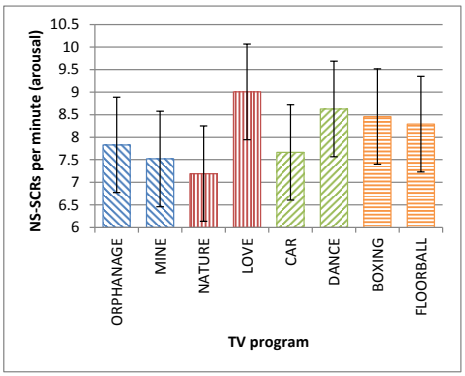


Figure 5.16: Number of NS-SCRs per minute (psychophysiological arousal) with 95% CIs for the programs.

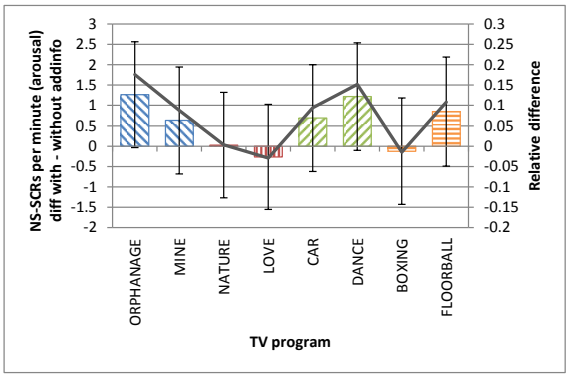


Figure 5.17: Mean difference of NS-SCRs per minute (psychophysiological arousal) with 95% CIs between conditions with - without ADDINFO for the programs. The gray line shows the relative difference.

Several participants would have liked to use a search bar to search for arbitrary additional information instead of reading only the automatically provided articles. On one hand, absence of such a feature may have given arise for the demand, but on the other hand, the demand is obvious as the participants had different informational needs that could not be fulfilled by the offered articles.

In contrast, some participants praised the convenience of the application as additional information is readily available and one does not need to do manual searches. Some participants reported that they would have searched exactly the same information as what was offered by the application. Some participants complimented that the application gave novel information which they would not have searched themselves.

Furthermore, many participants complained that the frequency of tablet content updates (mostly for the tweets) was too high, suggesting that the frequency has to be adjustable and match individual preferences. This is an obvious requirement as different people have different cognitive and attentional resources. Nevertheless, it is good to note that in the current study the participants' attention was drawn to the tablet somewhat forcibly by the flashing of the interface. Thus, the flashing may have contributed to the distraction caused by the high frequency of tablet content updates.

Chapter 6

Discussion

This chapter discusses and summarizes the results presented in Chapter 5 in the light of the research questions. Based on the results, recommendations for developing better second screen applications are given. Finally, limitations of the study and future work are discussed. The research questions defined in Section 1.2 are the following:

RQ 1. *What kind of effect does the presence of additional information have on media experience of TV programs?*

RQ 2. *What differences are there in media experience between TV genres, with respect to the presence of additional information? Consequently, are there genres that are better suited for additional information on second screen?*

RQ 3. *What kind of moderation effect do personality traits have on second screen use and associated media experience?*

6.1 Effect of additional information on media experience of TV programs

Apart from decreasing concentration on the TV program, the presence of additional information did not have any effect on the TV program related media experience variables (Table 5.3). The result implies that the participants were able to differentiate between the media experience of the TV program and the tablet contents. This is not a trivial result when taking into account the fact that as much as 40% of visual attention was drawn to the tablet when additional information was presented (Figure 5.11). Indeed, a decrease in the activity of orbicularis oculi muscle area (high arousal positive valence) when additional information was presented (Figure 5.15) may indicate that the participants were not

consciously aware that paying attention to additional information impaired the media experience associated with the TV program.

6.2 Differences between TV genres

Nevertheless, there were differences in additional information related media experience variables between the TV programs. These effects were present in additional information interestingness, trustworthiness, likability and the extent to which the participant felt the additional information was related to the TV program (Table 5.5). There were also marginal effects on perceived relevance and how much novel information the additional information gave. From the considerable number of effects, it is evident that there were programs for which additional information was a meaningful companion, and TV programs for which it was less so, with respect to the media experience of additional information.

In general, the additional information related media experience variables scored higher for the TV programs belonging to magazine and sports genres (Figure 5.4), suggesting that additional information suits these genres better. Previously, Miso [74] found that additional information presented on a second screen during broadcast works well with programs of these genres.

Differences in the scores of willingness to search for additional information resembled the general pattern in the additional information related media experience variables. Despite the non-significance, the participants' willingness to search for additional information was clearly higher in the case of magazine and sports programs, which further emphasizes the idea that additional information suits these genres better.

There are several possible reasons why additional information related media experience was better for magazine and sports programs, and less so for documentary and reality programs. As the use of additional information, as such, is driven by cognitive needs [70, 103, 115], one differentiating factor could be whether the TV program was associated with cognitive needs. As factual programming, magazines and documentaries are associated with cognitive needs but documentaries had generally lower additional information related media experience. Perhaps, the more entertaining and scripted nature of documentaries have caused the difference. Another important aspect is whether the TV program contains pauses to allow for switches in attention between the screens. The more scripted nature of documentaries and reality programs may not suit second screen use. Finally, information seeking behavior in relation to televised sports has been linked to personal integrity needs [56].

The mean score of most additional information related media experience variables was above the middle score (Figure 5.4). While the high mean scores may

be due the novelty of the situation (there were very few, if any, second screen applications in Finland at the time of the experiment), this suggests that additional information was not considered a nuisance. Indeed, the multitasking related variables indicated that the participants did not feel that additional information distracted TV viewing (Table 5.10).

On top of that, an interesting finding was that the participants felt that TV distracted tablet use, and the tablet was more likely considered to be the main screen when additional information was presented (Table 5.10). The programs for which the tablet was seen more likely as the main screen were the same programs that failed to appeal to the participants. This may be an indication of affective needs associated with second screen use. Participants attempted to counter the boredom of watching disengaging TV programs by reading more appealing tablet content [6, 113], and thus recognized the tablet as the main screen. The second screen may have a potential to become the main screen if the TV program is incapable of satisfying the viewer. However, as it is unlikely that people watch TV programs they regard boring, a more optimistic interpretation of the result would be that the second screen has a potential to keep the viewer engaged while the TV program is temporarily disengaging.

6.3 Effect of polychronicity on second screen use and associated media experience

Polychronicity had a significant effect on several measured variables including additional information novelty, likability, and experience enhancement variables (Table 5.7), number of bookmarked articles (Table 5.15), and both self-reported (Table 5.11) and gaze tracking based (see Section 5.3.1) visual attention on the tablet.

As more polychronous participants paid more attention on the tablet and also evaluated the media experience of additional information to be better, it appears that there is a direct relationship between how much attention is paid on additional information and how good media experience it can offer. Obviously, it is also true that less attention is given to unworthy additional information.

However, the presence of tweets alongside additional information also deteriorated the media experience of additional information (Figure 5.6) due attention being shared between the two tablet contents. This result supports the above postulation that the more attention is paid on additional information, the better the media experience associated with it. The relationship could be interpreted that increased attention on additional information lead to more cognitive gratifications to be obtained, and consequently, enhanced the media experience of additional information.

6.4 Recommendations

The recommendations based on the results of this study and previous research can be summarized as following:

- Additional information suits better magazine and sports genres than they do documentary and reality genres, and thus, should be offered alongside programs of these genres. However, this finding may only apply to additional information provided during the broadcast. Although not addressed in the this study, additional information may work with other genres as well when provided before or after the broadcast [74].
- Additional information should be provided only when the TV program is progressing slowly and the viewer is likely to be disengaged. The results on psychophysiological valence measures indicated that the TV program was less enjoyable when additional information was presented although the participants may not have been consciously aware of it.
- Different genres should be accompanied by different types of additional information, for example, quotes for comedy, gossip for reality, statistics for sports, and Wikipedia articles for news [74].
- It is recommended to have a bookmarking feature in a second screen application as it allows the user to concentrate on the TV program and return to interesting additional information later.
- Additional information should be short and concise so that users can consume the information efficiently. The more information is obtained from additional information, the more cognitive needs are fulfilled, and consequently, the better the media experience. However, on the other hand, too small amount of additional information may leave both cognitive and affective needs unsatisfied.
- Second screen content should be synchronized with the progress of the TV program as untimely content may degrade experience [8].
- Drawing attention forcibly to the second screen (e.g. by flashing) should be avoided as it distracts the user and degrades experience.
- The sources of additional information and the frequency of updates should be adjustable to match individual preferences. Taking personality traits into account may be useful in personalized second screen services.

6.5 Limitations

This study has possible limitations regarding experimental control. Although the TV programs were selected from specific genres and were limited in duration, they were not validated with respect to the content, particularly, amount of information, spatiotemporal structure, and affective properties. The sources of additional information were limited to online news and Wikipedia articles, which presumably contain formal language, and the outlook of the articles was ensured to be consistent. Yet, the articles also remain unvalidated with respect to the amount of information, structure, and affective properties. The lack of validation makes it difficult to identify the factors behind the differences in media experience of TV programs and additional information.

As noted already in Section 3.3, the sample was unbalanced with respect to age, gender, education, and profession. Moreover, the proportion of the participants owning a tablet was extraordinarily large. While the sample deviates from the general population, it was suitable for the current experiment as it represented typical, technologically oriented second screen users. Furthermore, it can be argued that the results of this study may apply to the general population in the future when second screen practice is much more common.

6.6 Future work

More detailed temporal analysis of the psychophysiological data and eye tracking data is worth performing as temporal specificity is one of the key benefits of these measurements. Temporal analysis may reveal short-term differences in psychophysiological responses and visual attention while watching TV and reading additional information articles. By combining the temporal analysis with automatic content analysis of the TV programs, it may be possible to identify specific features in the programs that affect attention and engagement (or disengagement).

The influence of media multitasking and second screen use on performance has been studied considerably more than the experience associated with the practices. Recently, the interest of the TV industry towards media multitasking and second screen has yielded several surveys on the topics. However, it can be argued that there is a need for further empirical studies on the experience of media multitasking. As the recent second screen studies have been driven mainly by the combination of TV and social media, such as Twitter, more attention should be given to additional information as second screen content. Moreover, the effect of personality traits on media experience, a topic that is easily neglected, requires further addressing.

Chapter 7

Conclusions

This study took an exploratory approach to investigating the media experience of TV viewing and simultaneous consumption of additional information on a second screen tablet application. The Model of Media Experience was selected as the research framework as it applies well to diversity of media and is able to capture various aspects of media experience. Furthermore, the results were discussed and interpreted through the uses and gratifications theory. An experiment was carried out, in which the participants watched TV programs and, at the same time, interacted freely with a tablet application that presented TV program related additional information and tweets. The experiment employed several methods to measure media experience including self-reports, psychophysiological measurements, and eye tracking. Due to unavailability of suitable existing second screen applications and contents, a custom second screen application and second screen environment was developed.

As a summary of the results, the presence of additional information did not have any effect on the self-reported media experience of the TV programs. However, positive psychophysiological valence was reduced when additional information was presented. The contradictory findings suggest that the participants were not consciously aware that attending additional information impaired the media experience of TV viewing.

Media experience of additional information was generally better in the case of magazine and sports genres than for documentary and reality genres, suggesting that additional information suits better TV programs belonging to the former two genres. Furthermore, it appeared that attention on additional information had a direct relationship with the media experience of additional information. In other words, the more attention was given to additional information, the better its media experience was.

Finally, the presence of additional information was not found to be distracting TV viewing but on the contrary, TV was perceived to be distracting tablet

use when additional information was presented. The tablet apparently had a potential to become the main screen when the TV program failed to appeal to the participants.

Based on these results, it is recommended that additional information is accompanied with TV programs belonging to magazine and sports genres during the broadcast. However, additional information may work with other genres as well outside the airing time. Additional information should be short and concise to satisfy the cognitive needs more efficiently, which consequently leads to enhanced media experience. Drawing attention to the second screen forcibly distracts the viewer and thus, should be avoided. Second screen application should be customizable to match individual preferences as well as cognitive and attentional resources. Finally, as personality traits, such as polychronicity, clearly influence media experience, they should be taken into account when implementing personalized second screen services.

Bibliography

[1] W. Albert and T. Tullis. *Measuring the user experience: collecting, analyzing, and presenting usability metrics*. Newnes, 2013.

[2] ANSLAB. Anslab documentation: Electrocardiography. URL `http://www.anslab.net/static/help/cardiography.html`.

[3] T. Aue, A. Flykt, and K. R. Scherer. First evidence for differential and sequential efferent effects of stimulus relevance and goal conduciveness appraisal. *Biological Psychology*, 74(3):347–357, 2007.

[4] S. A. Ball and M. Zuckerman. Sensation seeking and selective attention: Focused and divided attention on a dichotic listening task. *Journal of Personality and Social Psychology*, 63(5):825–831, 1992.

[5] F. Bardhi, A. J. Rohm, and F. Sultan. Tuning in and tuning out: media multitasking among young consumers. *Journal of Consumer Behaviour*, 9 (4):316–332, 2010.

[6] N. Baron. Adjusting the volume: Technology and multitasking in discourse control. *Handbook of mobile communication studies*, pages 177–193, 2008.

[7] S. Basapur, G. Harboe, H. Mandalia, A. Novak, V. Vuong, and C. Metcalf. Field trial of a dual device user experience for itv. In *Proceedings of the 9th International Interactive Conference on Interactive Television*, EuroITV '11, pages 127–136, New York, NY, USA, 2011. ACM.

[8] S. Basapur, H. Mandalia, S. Chaysinh, Y. Lee, N. Venkitaraman, and C. Metcalf. Fanfeeds: Evaluation of socially generated information feed on second screen as a tv show companion. In *Proceedings of the 10th European Conference on Interactive TV and Video*, EuroiTV '12, pages 87–96, New York, NY, USA, 2012. ACM.

[9] M. Benedek and C. Kaernbach. A continuous measure of phasic electrodermal activity. *Journal of Neuroscience Methods*, 190(1):80–91, 2010.

[10] G. G. Berntson, K. S. Quigley, J. F. Jang, and S. T. Boysen. An approach to artifact identification: Application to heart period data. *Psychophysiology*, 27(5):586–598, 1990.

[11] G. G. Berntson, J. T. Cacioppo, and K. S. Quigley. The metrics of cardiac chronotropism: Biometric perspectives. *Psychophysiology*, 32(2):162–171, 1995.

[12] G. G. Berntson, J. Thomas Bigger, D. L. Eckberg, P. Grossman, P. G. Kaufmann, M. Malik, H. N. Nagaraja, S. W. Porges, J. P. Saul, P. H. Stone, and M. W. Van Der Molen. Heart rate variability: Origins, methods, and interpretive caveats. *Psychophysiology*, 34(6):623–648, 1997.

[13] F. Biocca, C. Harms, and J. Gregg. The networked minds measure of social presence: Pilot test of the factor structure and concurrent validity. In *4th annual International Workshop on Presence, Philadelphia, PA*, 2001.

[14] A. C. Bluedorn. *The Human Organization of Time: Temporal Realities and Experience*. Stanford business books. Stanford Business Books, 2002.

[15] A. C. Bluedorn, T. J. Kalliath, M. J. Strube, and G. D. Martin. Polychronicity and the inventory of polychronic values (ipv): The development of an instrument to measure a fundamental dimension of organizational culture. *Journal of Managerial Psychology*, 14(3/4):205–231, 1999.

[16] P. D. Bolls, A. Lang, and R. F. Potter. The effects of message valence and listener arousal on attention, memory, and facial muscular responses to radio advertisements. *Communication Research*, 28(5):627–651, 2001.

[17] W. Boucsein. *Electrodermal Activity*. The Springer series in behavioral psychophysiology and medicine. Springer, 2012.

[18] S. A. Brasel and J. Gips. Media multitasking behavior: Concurrent television and computer usage. *Cyberpsy., Behavior, and Soc. Networking*, 14(9):527–534, 2011.

[19] T. Buser and N. Peter. Multitasking. *Experimental Economics*, 15(4):641–655, 2012.

[20] J. T. Cacioppo, W. L. Gardner, and G. G. Berntson. The affect system has parallel and integrative processing components: Form follows function. *Journal of personality and Social Psychology*, 76(5):839, 1999.

[21] C. S. Carver and T. L. White. Behavioral inhibition, behavioral activation, and affective responses to impending reward and punishment: The bis/bas scales. *Journal of Personality and Social Psychology*, 67(2):319–333, 1994.

[22] P. Cesar, D. C. Bulterman, and A. J. Jansen. Usages of the secondary screen in an interactive television environment: Control, enrich, share, and transfer television content. In *Proceedings of the 6th European conference on Changing Television Environments*, EUROITV '08, pages 168–177, Berlin, Heidelberg, 2008. Springer-Verlag.

[23] A. Charland and B. Leroux. Mobile application development: Web vs. native. *Commun. ACM*, 54(5):49–53, May 2011.

[24] J. Cohen. A power primer. *Psychological bulletin*, 112(1):155–159, 1992.

[25] J. M. Conte and J. N. Gintoft. Polychronicity, big five personality dimensions, and sales performance. *Human Performance*, 18(4):427–444, 2005.

[26] J. M. Conte and R. R. Jacobs. Validity evidence linking polychronicity and big five personality dimensions to absence, lateness, and supervisory performance ratings. *Human Performance*, 16(2):107–129, 2003.

[27] L. Cruickshank, E. Tsekleves, R. Whitham, A. Hill, and K. Kondo. Making interactive tv easier to use: Interface design for a second screen approach. *The Design Journal*, 10(3):41–53, 2007.

[28] M. E. Dawson, A. M. Schell, and D. L. Filion. The electrodermal system. *Handbook of psychophysiology*, pages 200–223, 2007.

[29] E. D'heer, C. Courtois, and S. Paulussen. Everyday life in (front of) the screen: the consumption of multiple screen technologies in the living room context. In *Proceedings of the 10th European conference on Interactive TV and video*, EuroiTV '12, pages 195–198, New York, NY, USA, 2012. ACM.

[30] E. D'heer, C. Courtois, and S. Paulussen. The dynamics of multi-screen media consumption in the living room context. In *Etmaal van de communicatiewetenschap, Proceedings*, page 20. Ghent University, Department of Communication studies, 2012.

[31] A. T. Duchowski. *Eye Tracking Methodology: Theory and Practice*. Springer-Verlag New York, Inc., Secaucus, NJ, USA, 2007.

[32] R. Edelberg. Electrical properties of the skin. *Methods in psychophysiology*, pages 1–53, 1967.

[33] M. Efron. Hashtag retrieval in a microblogging environment. In *Proceedings of the 33rd International ACM SIGIR Conference on Research and Development in Information Retrieval*, SIGIR '10, pages 787–788, New York, NY, USA, 2010. ACM.

[34] P. Ekman, R. J. Davidson, and W. V. Friesen. The duchenne smile: Emotional expression and brain physiology: Ii. *Journal of personality and social psychology*, 58(2):342, 1990.

[35] H. J. Eysenck. *The Biological Basis of Personality*. American Lecture Series. Publication. Thomas, 1967.

[36] S. Fallahkhair, L. Pemberton, and R. Griffiths. Dual device user interface design for ubiquitous language learning: mobile phone and interactive television (itv). In *Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on*, pages 85–92, 2005.

[37] A. Field. *Discovering Statistics Using SPSS*. Introducing Statistical Methods. SAGE Publications Ltd, 2009.

[38] U. G. Foehr. *Media multitasking among American youth: Prevalence, predictors and pairings*. Henry J. Kaiser Family Foundation, Menlo Park, CA, 2006.

[39] K. Foerde, B. J. Knowlton, and R. A. Poldrack. Modulation of competing memory systems by distraction. *Proceedings of the National Academy of Sciences*, 103(31):11778–11783, 2006.

[40] L. W. Freedman, A. S. Scerbo, M. E. Dawson, A. Raine, W. O. McClure, and P. H. Venables. The relationship of sweat gland count to electrodermal activity. *Psychophysiology*, 31(2):196–200, 1994.

[41] A. Friedman and L. S. Liebelt. On the time course of viewing pictures with a view towards remembering. *Eye movements: Cognition and visual perception*, pages 137–155, 1981.

[42] D. Geerts, P. Cesar, and D. Bulterman. The implications of program genres for the design of social television systems. In *Proceedings of the 1st International Conference on Designing Interactive User Experiences for TV and Video*, UXTV '08, pages 71–80, New York, NY, USA, 2008. ACM.

[43] Google. The new multi-screen world: Understanding cross-platform consumer behavior. Technical report, Google, Sterling Brands, Ipsos, 2012. URL `http://ssl.gstatic.com/think/docs/the-new-multi-screen-world-study_research-studies.pdf`.

[44] J. A. Gray. Brain systems that mediate both emotion and cognition. *Cognition & Emotion*, 4(3):269–288, 1990.

[45] J. A. Gray. The neuropsychology of temperament. In *Explorations in temperament*, pages 105–128. Springer, 1991.

[46] D. W. Hansen and Q. Ji. In the eye of the beholder: A survey of models for eyes and gaze. *IEEE Trans. Pattern Anal. Mach. Intell.*, 32(3):478–500, March 2010.

[47] L. K. Harrison, D. Carroll, V. E. Burns, A. R. Corkill, C. M. Harrison, C. Ring, and M. Drayson. Cardiovascular and secretory immunoglobulin a reactions to humorous, exciting, and didactic film presentations. *Biological Psychology*, 52(2):113–126, 2000.

[48] M. Helle, N. Ravaja, H. Heikkilä, J. Kallenbach, A. Kankainen, J. Kätsyri, J. Laine, and D. Marghescu. A theoretical model of media experience and research methods for studying it. Technical report, Next Media, 2011.

[49] M. Helle, N. Ravaja, H. Heikkilä, J. Kallenbach, J. Kätsyri, J. Laine, D. Marghescu, A. Mensonen, M. Aikala, and T. Saari. Detailed plan of the empirical studies. Technical report, Next Media, 2011.

[50] K. Holmqvist, M. Nystrom, R. Andersson, R. Dewhurst, H. Jarodzka, and J. van de Weijer. *Eye Tracking. A comprehensive guide to methods and measures*. Oxford University Press, 2011.

[51] R. Hopkins and J. E. Fletcher. Electrodermal measurement: Particularly effective for forecasting message influence on sales appeal. 1994.

[52] M. S. Humphreys and W. Revelle. Personality, motivation, and performance: a theory of the relationship between individual differences and information processing. *Psychological review*, 91(2):153, 1984.

[53] S. T. Iqbal, J. Grudin, and E. Horvitz. Peripheral computing during presentations: Perspectives on costs and preferences. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '11, pages 891–894, New York, NY, USA, 2011. ACM.

[54] D. E. Irwin. Visual memory within and across fixations. In *Eye movements and visual cognition*, pages 146–165. Springer, 1992.

[55] J. R. Jennings, W. K. Berg, J. S. Hutcheson, P. Obrist, S. Porges, and G. Turpin. Publication guidelines for heart rate studies in man. *Psychophysiology*, 18(3):226–231, 1981.

[56] A. N. Joinson. Information seeking on the internet: a study of soccer fans on the www. *CyberPsychology and Behavior*, 3(2):185–190, 2000.

[57] E. Katz, J. G. Blumler, and M. Gurevitch. Utilization of mass communication by the individual. In J. G. Blumler and E. Katz, editors, *The Uses of Mass Communication*, pages 19–32. Sage Publications, Beverly Hills, 1974.

[58] C. Kaufman-Scarborough and J. D. Lindquist. Time management and polychronicity: Comparisons, contrasts, and insights for the workplace. *Journal of Managerial Psychology*, 14(3/4):288–312, 1999.

[59] R. Kohvakka, P. Melkas, and R. Harala. Suomen virallinen tilasto (svt): Väestön tieto- ja viestintätekniikan käyttö -tutkimus 2011. Technical report, Statistics Finland, 2011. URL `http://tilastokeskus.fi/til/sutivi/2011/sutivi_2011_2011-11-02_tau_001_fi.html`.

[60] R. Kohvakka, P. Melkas, and R. Harala. Suomen virallinen tilasto (svt): Väestön tieto- ja viestintätekniikan käyttö -tutkimus 2012. Technical report, Statistics Finland, 2012. URL `http://tilastokeskus.fi/til/sutivi/2012/sutivi_2012_2012-11-07_tau_002_fi.html`.

[61] R. Kohvakka, P. Melkas, and R. Harala. Suomen virallinen tilasto (svt): Väestön tieto- ja viestintätekniikan käyttö -tutkimus 2013. Technical report, Statistics Finland, 2013. URL `http://tilastokeskus.fi/til/sutivi/2013/sutivi_2013_2013-11-07_tau_001_fi.html`.

[62] C. J. König and M. J. Waller. Time for reflection: A critical examination of polychronicity. *Human Performance*, 23(2):173–190, 2010.

[63] M. Laine-Hernandez, T. Kinnunen, K. Kusumoto, W. S. Kätsyri, Jari, N. Ravaja, and P. Oittinen. Multitasking influence on engagement. Technical report, Next Media, 2013.

[64] A. Lang. The limited capacity model of mediated message processing. *Journal of Communication*, 50(1):46–70, 2000.

[65] P. J. Lang. *Behavioral treatment and bio-behavioral assessment: computer applications*, pages 119–l37. Ablex, 1980.

[66] P. J. Lang. The emotion probe: Studies of motivation and attention. *American psychologist*, 50(5):372, 1995.

[67] P. J. Lang, M. K. Greenwald, M. M. Bradley, and A. O. Hamm. Looking at pictures: Affective, facial, visceral, and behavioral reactions. *Psychophysiology*, 30(3):261–273, 1993.

[68] R. J. Larsen and E. Diener. Promises and problems with the circumplex model of emotion. 1992.

[69] F. J. Lee and N. A. Taatgen. Multitasking as skill acquisition. In *Proceedings of the twenty-fourth annual conference of the cognitive science society*, pages 572–577, 2002.

[70] S. Lim. How and why do college students use wikipedia? *Journal of the American Society for Information Science and Technology*, 60(11):2189–2202, 2009.

[71] P. Lubbers and F. Greco. Html5 web sockets: A quantum leap in scalability for the web. URL `http://www.websocket.org/quantum.html`.

[72] M. Martin. Individual differences in sensation seeking and attentional ability. *Personality and Individual Differences*, 6(5):637–639, 1985.

[73] S. Meri. Media experience on tablet devices - towards affect-adaptive applications. Master's thesis, Aalto University School of Science, 2012.

[74] Miso. The miso sync experiment: Delivering real-time, relevant information on the second screen. Technical report, Miso, 2011. URL `http://dl.dropboxusercontent.com/u/2849649/The_Miso_Sync_Experiment.pdf`.

[75] Nielsen. The cross-platform report q2 2012. Technical report, Nielsen, 2012. URL `http://www.nielsen.com/us/en/reports/2012/state-of-the-media--cross-platform-report-q2-2012.html`.

[76] Nielsen. The follow-back: Understanding the two-way causal influence between twitter activity and tv viewership. Technical report, Nielsen, 2013. URL `http://www.nielsen.com/us/en/newswire/2013/the-follow-back--understanding-the-two-way-causal-influence-betw.html`.

[77] D. Novak, M. Mihelj, and M. Munih. Dual-task performance in multimodal human-computer interaction: A psychophysiological perspective. *Multimedia Tools Appl.*, 56(3):553–567, February 2012.

[78] T. P. Novak and D. L. Hoffman. Measuring the flow experience among web users. *Interval Research Corporation*, 31, 1997.

[79] H. L. O'Brien and E. G. Toms. The development and evaluation of a survey to measure user engagement. *Journal of the American Society for Information Science and Technology*, 61(1):50–69, 2010.

[80] A. Öhman. The orienting response, attention, and learning: An information processing perspective. *The orienting reflex in humans*, pages 443–471, 1979.

[81] E. Ophir, C. Nass, and A. D. Wagner. Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, 2009.

[82] J. Papillo and D. Shapiro. Principles of psychophysiology: Physical, social and inferential elements, chapter the cardiovascular system, 1990.

[83] H. Pashler. Dual-task interference in simple tasks: data and theory. *Psychological bulletin*, 116(2):220, 1994.

[84] S. C. Payne and J. Philo. Identifying those who prefer to do more with less. Paper presented at the 17th annual convention of the Society of Industrial and Organizational Psychology, 2002.

[85] E. M. Perse. Sensation seeking and the use of television for arousal. *Communication Reports*, 9(1):37–48, 1996.

[86] E. M. Poposki and F. L. Oswald. The multitasking preference inventory: Toward an improved measure of individual differences in polychronicity. *Human Performance*, 23(3):247–264, 2010.

[87] S. W. Porges. Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. a polyvagal theory. *Psychophysiology*, 32(4): 301–318, 1995.

[88] M. Proulx and S. Shepatin. *Social TV: How Marketers Can Reach and Engage Audiences by Connecting Television to the Web, Social Media, and Mobile*. Wiley, 2012.

[89] Radiocommunication Sector of ITU. Recommendation itu-r bt.2022: General viewing conditions for subjective assessment of quality of sdtv and hdtv television pictures on flat panel displays. Technical report, International Telecommunication Union, 2012.

[90] N. Ravaja. Contributions of psychophysiology to media research: Review and recommendations. *Media Psychology*, 6(2):193–235, 2004.

[91] N. Ravaja. Effects of a small talking facial image on autonomic activity: The moderating influence of dispositional bis and bas sensitivities and emotions. *Biological Psychology*, 65(2):163–183, 2004.

[92] Red Bee Media and Decipher. Tv and the second screen. Technical report, MIPTV-MIPCOM, 2012.

[93] V. J. Rideout, U. G. Foehr, and D. F. Roberts. Generation m2: Media in the lives of 8-to 18-year-olds. *Henry J. Kaiser Family Foundation*, 2010.

[94] D. F. Roberts. *Kids and Media at the New Millennium*. A Kaiser Family Foundation report, November 1999. Henry J. Kaiser Family Foundation, 1999.

[95] S. Robertson, C. Wharton, C. Ashworth, and M. Franzke. Dual device user interface design: Pdas and interactive television. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, CHI '96, pages 79–86, New York, NY, USA, 1996. ACM.

[96] E. M. Rogers. *Diffusion of Innovations*. Free Press, 5th edition, 2003.

[97] G. Rowland, G. Fouts, and T. Heatherton. Television viewing and sensation seeking: Uses, preferences and attitudes. *Personality and Individual Differences*, 10(9):1003–1006, 1989.

[98] J. Salminen and T. Vaulos. Soneran koti ja tv -tutkimus 2012. Technical report, Sonera, TNS Gallup, 2012. URL `http://mb.cision.com/Public/145/9298248/b709e1fc921675e2.pdf`.

[99] A. Santella and D. DeCarlo. Robust clustering of eye movement recordings for quantification of visual interest. In *Proceedings of the 2004 symposium on Eye tracking research & applications*, pages 27–34. ACM, 2004.

[100] A. S. Scerbo, L. W. Freedman, A. Raine, M. E. Dawson, and P. H. Venables. A major effect of recording site on measurement of electrodermal activity. *Psychophysiology*, 29(2):241–246, 1992.

[101] K. R. Scherer. Neuroscience projections to current debates in emotion psychology. *Cognition & Emotion*, 7(1):1–41, 1993.

[102] N. Schneiderman. Cardiovascular psychophysiology: A perspective, 1982.

[103] A. Spink. Multitasking information behavior and information task switching: an exploratory study. *Journal of documentation*, 60(4):336–351, 2004.

[104] S. S. Sundar and A. M. Limperos. Uses and grats 2.0: New gratifications for new media. *Journal of Broadcasting & Electronic Media*, 57(4):504–525, 2013.

[105] B. Szymura and E. Necka. Visual selective attention and personality: An experimental verification of three models of extra version. *Personality and Individual Differences*, 24(5):713–729, 1998.

[106] L. G. Tassinary, J. T. Cacioppo, and E. J. Vanman. The skeletomotor system: Surface electromyography. *Handbook of psychophysiology*, pages 267–299, 2007.

[107] J. R. Turner. *Cardiovascular Reactivity and Stress:: Patterns of Physiological Response*. Springer, 1994.

[108] A. van Boxtel. Optimal signal bandwidth for the recording of surface emg activity of facial, jaw, oral, and neck muscles. *Psychophysiology*, 38(1):22–34, 2001.

[109] A. van Boxtel. Facial emg as a tool for inferring affective states. In *Proceedings of measuring behavior*, volume 2010, pages 104–108. Noldus Information Technology Wageningen, 2010.

[110] M. Viitanen, S. Westman, T. Kinnunen, and P. Oittinen. Features of media multitasking experiences. Technical report, Next Media, 2012.

[111] P. Vorderer, W. Wirth, F. R. Gouveia, F. Biocca, T. Saari, L. Jäncke, S. Böcking, H. Schramm, A. Gysbers, T. Hartmann, C. Klimmt, J. Laarni, N. Ravaja, A. Sacau, T. Baumgartner, and P. Jäncke. Mec spatial presence questionnaire (meq-spq): Short documentation and instructions for application. 2004.

[112] N. Walley, L. Mason, H. McPharlin, P. Epailly, S. Medlicott, and K. Hardiman. Red bee media second screen series - paper 2: Dual screen consumers. Technical report, Red Bee Media, 2012. URL `http://www.redbeemedia.com/news/broadcast-industry-not-capitalising-rise-second-screen`.

[113] Z. Wang and J. M. Tchernev. The myth of media multitasking: Reciprocal dynamics of media multitasking, personal needs, and gratifications. *Journal of Communication*, 62(3):493–513, 2012.

[114] D. Watson, D. Wiese, J. Vaidya, and A. Tellegen. The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. *Journal of personality and social psychology*, 76 (5):820, 1999.

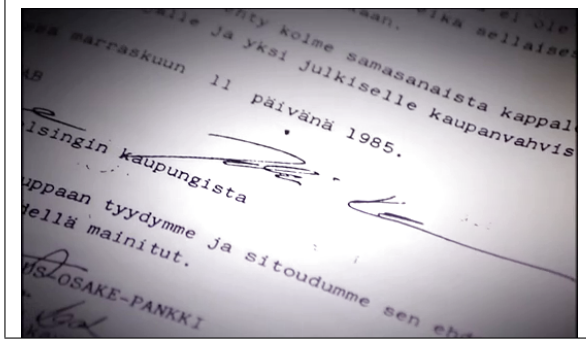
[115] C. Y. Yoo. Modeling audience interactivity as the gratification-seeking process in online newspapers. *Communication Theory*, 21(1):67–89, 2011.

[116] D. Zillmann. Television viewing and physiological arousal. *Responding to the screen: Reception and reaction processes*, pages 103–133, 1991.

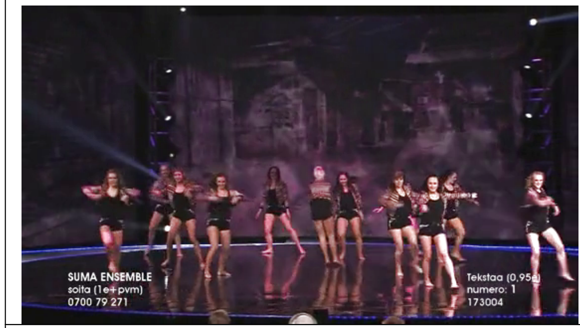
Appendix A

Stimulus TV programs

Table A.1: The stimulus TV programs.

Image	Description	Genre
	1. MOT (label: ORPHANAGE): a magazine program by YLE that reports societal problems by the means of investigative journalism. The episode uncovers how the Bensow orphanage foundation defrauded the Bensow orphanage of 25 million euros.	Magazine (Finnish: ajankohtaisohjelma)

	2. Suora linja (label: MINE): a magazine program by YLE that handles topical discussions in social media. The episode criticizes the accidental leak in a gypsum pond of the Finnish mining company Talvivaara and presents tweets on the topic and interviews of Talvivaara employees.	Magazine
	3. Avara luonto (label: NATURE): a nature documentary series bought from abroad and dubbed in Finnish. The episode talks about the barnacle goose that has inhabited the urban areas of Helsinki and causes aesthetic damage to the scenery by feces.	Documentary (Finnish: dokumentti)
	4. Totuus rakkaudesta (label: LOVE): An entertainment documentary series by YLE that interviews Finnish celebrities and asks their opinion on various topics of love and relationship. The episode discusses the realities of partners moving in and living together. The program has a humorous tone.	Documentary

	5. Latela (label: CAR): A reality program which documents the competition of two teams that have to build a car within a month with 3000 euros to be exhibited at the American Car Show event. In the episode the teams have finished their cars and gather votes from the event visitors at the American Car Show.	Reality (Finnish: tosi-TV)
	6. Pakko tanssia (label: DANCE): YLE's dance competition program that is a Finnish version of the British Got to Dance program format. The semi-final episode in which the dance team Suma Ensemble performs its modern jazz style dance.	Reality
	7. Boxing (label: BOXING): a heavyweight European title match between Finnish Robert Helenius and British Michael Sprott.	Sports (Finnish: urheilu)

	8. Floorball (label: FLOORBALL): a floorball match between the national teams of Finland and Sweden in European Floorball Tour 2013.	Sports

Appendix B

Self-report measures

B.1 Sociodemographics

Table B.1: The sociodemographics (pre-experiment) questionnaire. The participants were asked to fill out this questionnaire in the Google Forms service prior to participating to the experiment.

Item in English	**Options in English**	**Item in Finnish**	**Options in Finnish**
1. Gender.	Female; Male	1. Sukupuolesi	Nainen; Mies
2. Age.		2. Ikäsi	
3. Handedness.	Right; Left; Neither	3. Oletko oikea- vai vasenkätinen?	Oikeakätinen; Vasenkätinen; En kumpaakaan

4. If you have degraded hearing or vision, select which you have.	Prescription glasses (myopia); Prescription glasses (hyperopia); I will use contact lenses during the experiment; Vision corrected by surgery; I have been diagnosed with degraded hearing; I will use hearing aid during the experiment; Normal vision	4. Jos sinulla on alentunut kuulo- tai näkökynnys; merkitse mitkä.	Silmälasit (lähinäköä korjaavat); Silmälasit (kaukonäköä korjaavat); Kokeessa tulen käyttämään piilolinssejä; Olen käynyt näköä korjaavassa silmäleikkauksessa; Minulla on todettu alentunut kuuloaisti; Kokeessa tulen käyttämään kuulolaitetta; Näköni on ok, en käytä silmälaseja
5. Education.	Elementary school; Gymnasium; Vocational school; Polytechnic; Bachelor's degree; Master's degree; Licentiate or doctorate	5. Koulutus	Kansakoulu tai peruskoulu; Lukio; Ammattikoulu; Opisto- tai ammattikorkeakoulututkinto; Alempi korkeakoulututkinto; Ylempi korkeakoulututkinto; Lisensiaatin- tai tohtorintutkinto
6. Profession.	Pedagogics; Humanities; Arts; Commerce; Social science; Engineering; Natural science; Agriculture and forestry; Health care and social services; Service or other	6. Koulutus- tai ammattiala	Kasvatustieteellinen; Humanistinen; Taide; Kaupallinen; Yhteiskuntatieteellinen; Teknillinen; Luonnontieteellinen; Maa- ja metsätalous; Terveys ja sosiaali; Palvelu tai Muu

7. Estimate how much do you use a computer daily on average.	4 hours of less; 4-5 hours; 7-8 hours; 9-10 hours; 11-12 hours; 13 hours or more	7. Arvioi kuinka paljon käytät tietokonetta keskimäärin päivän aikana?	4 tai vähemmän; 4-6 tuntia; 7-8 tuntia; 9-10 tuntia; 11-12 tuntia; 13 tai enemmän
8. How much do you use different media daily on average?	I don't use any media; Max 2 hours, Max 4 hours, Max 6 hours; Max 8 hours, Max 10 hours; Max 12 hours; Max 14 hours; More than 14 hours	8. Kuinka paljon käytät eri medioita keskimäärin päivän aikana?	En koe käyttäväni mitään mediaa; Korkeintaan 2h päivässä; Korkeintaan 4h päivässä; Korkeintaan 6h päivässä; Korkeintaan 8h päivässä; Korkeintaan 10h päivässä; Korkeintaan 12h päivässä; Korkeintaan 14h päivässä; Enemmän kuin 14h päivässä
9. Do you own a tablet. If you do, estimate how much you use it.	I don't own a tablet; Many times a day; Once a day; Couple of times a week; Once a week; Once a month; Seldom; Never	9. Omistatko jonkin tablet-laitteen? Jos omistat, arvioi kuinka paljon käytät sitä keskimäärin?	En omista; Useita kertoja päivässä; Kerran päivässä; Muutaman kerran viikossa; Kerran viikossa; Kerran kuukaudessa; Harvemmin; En koskaan

10. I usually use the following devices to watch TV.	TV; Computer; + Laptop; + Desktop; + Mobile phone; + Tablet; I don't watch TV; I don't own a TV	10. Tyypillisesti TV:tä katsoessani käytän seuraavia laitteita	TV; Katson ohjelmat tietokoneelta (Yle Areena, MTV3 Katsomo, Netflix, w4reZ...); + Kannettava tietokone; + Pöytäkone; + Kännykkä; + Tabletti; En koe katsovani TV-ohjelmia; En omista TV:tä
11. When I watch TV accompanied by a smart device the main media is the following.	Usually the TV; Usually the smart device	11. Kun katson TV:tä äly-laitteen kanssa, koen että päämedia on...	Useimmiten TV; Useimmiten äly-laite
12. While watching TV I use other devices at the same time.	Very often; Often; Occasionally; Seldom; Very seldom; I don't use other devices while watching TV	12. Käytän muita laitteita (tablet, kännykkä, kannettavatietokone...) samaan aikaan, kun katson TV:tä.	Hyvin usein; Melko usein; Joskus; Melko harvoin; Hyvin harvoin; En käytä muita laitteita, kun katson TV:tä
13. While watching TV I use other devices for activities that are related to the TV content.	5-point Likert scale: 1 = related to TV content, 5 = unrelated to TV content	13. Kun katson TV:tä, käytän muita laitteita tarkoitusperiin, jotka...	1 = liittyvät TV:n sisältöön, 5 = eivät liity TV:n sisältöön

14. I search for information related to the TV program I watch.	Very often; Often; Occasionally; Seldom; Very seldom; I don't search for information	14. Kun katson TV:tä, haen tietoa liittyen TV-ohjelmaan, jota katson.	Hyvin usein; Melko usein; Joskus; Melko harvoin; Hyvin harvoin; En hae tietoa, kun katson TV:tä
15. While watching TV I use the following services to search for information related to the TV program I watch.	Web search engines; Wikipedia; Online newspapers; News aggregation sites; Blogs; Social media; Online stores; Price comparison sites; IMDb; TV program sites; TV channel sites; TV guides; Sports statistics sites; I don't search for information; Other	15. Kun katson TV:tä, käytän seuraavia palveluita hakiessani tietoa liittyen TV-ohjelmaan, jota katson.	Web-hakukoneet (Google, Yahoo!, Bing...); Wikipedia; Verkkolehdet (Helsingin Sanomat, Kauppalehti, Iltalehti...); Uutissivustot (Ampparit.com, UutisAalto...); Blogit; Sosiaalinen media (Facebook, Twitter, LinkedIn...); Verkkokaupat; Hintavertailusivustot; IMDb; TV-ohjelmien sivustot; TV-kanavien sivustot (Yle, MTV3, Nelonen...); TV-ohjelmaoppaat; Urheilutulossivustot; En hae tietoa, kun katson TV:tä; Other

B.2 BIS/BAS scales

Table B.2: The BIS/BAS scales [21]. The filler items in the original scales were removed. A 4-point Likert scale: 1 = very false for me (Finnish: ei pidä ollenkaan paikkaansa minun kohdallani), 2 = somewhat false for me (pitää melko huonosti paikkansa minun kohdallani), 3 = somewhat true for me (pitää melko hyvin paikkansa minun kohdallani), 4 = very true for me (pitää täysin paikkansa minun kohdallani)

Item in English	**Item in Finnish**
1. Even if something bad is about to happen to me, I rarely experience fear or nervousness. (reversed)	1. Vaikka minulle olisi tapahtumassa jotakin ikävää, tunnen itseni vain harvoin pelokkaaksi tai hermostuneeksi.
2. I go out of my way to get things I want.	2. Olen valmis näkemään paljon vaivaa saadakseni sen mitä haluan.
3. When I'm doing well at something I love to keep at it.	3. Kun jokin asia sujuu minulta hyvin, jatkan erittäin mielelläni sen tekemistä.
4. I'm always willing to try something new if I think it will be fun.	4. Olen aina halukas kokeilemaan jotakin uutta, mikäli uskon sen olevan hauskaa.
5. When I get something I want, I feel excited and energized.	5. Kun saan jotakin mitä haluan, tunnen itseni innostuneeksi ja energiseksi.
6. Criticism or scolding hurts me quite a bit.	6. Saamani kritiikki tai moitteet pahoittavat mieltäni aika tavalla.
7. When I want something I usually go all-out to get it.	7. Halutessani jotakin teen yleensä kaikkeni saadakseni sen.
8. I will often do things for no other reason than that they might be fun.	8. Teen usein asioita vain sen vuoksi, että ne voivat olla hauskoja.
9. If I see a chance to get something I want I move on it right away.	9. Jos huomaan tilaisuuden saada jotakin mitä haluan, toimin välittömästi saadakseni sen.
10. I feel pretty worried or upset when I think or know somebody is angry at me.	10. Olen melko huolissani tai järkyttynyt, mikäli luulen tai tiedän jonkun olevan vihainen minulle.

11. When I see an opportunity for something I like I get excited right away.	11. Kun näen mahdollisuuden johonkin mistä pidän, tulen heti kiihtyneeksi.
12. I often act on the spur of the moment.	12. Toimin usein hetken mielijohteesta.
13. If I think something unpleasant is going to happen I usually get pretty "worked up."	13. Jos ajattelen, että jotakin epämiellyttävää tulee tapahtumaan, tulen tavallisesti varsin hermostuneeksi.
14. When good things happen to me, it affects me strongly.	14. Kun minulle tapahtuu jotakin hyvää, se vaikuttaa minuun voimakkaasti.
15. I feel worried when I think I have done poorly at something important.	15. Tunnen itseni huolestuneeksi, kun koen suoriutuneeni huonosti jossakin tärkeässä asiassa.
16. I crave excitement and new sensations.	16. Janoan jännitystä ja uusia kokemuksia.
17. When I go after something I use a "no holds barred" approach.	17. Kun tavoittelen jotakin, niin mikään ei pidättele minua.
18. I have very few fears compared to my friends. (reversed)	18. Pelkään hyvin harvoja asioita verrattuna ystäviini.
19. It would excite me to win a contest.	19. Minusta olisi jännittävää voittaa jokin kilpailu.
20. I worry about making mistakes.	20. Olen huolissani siitä, että saatan tehdä virheitä.

B.3 Multitasking preference inventory

Table B.3: The multitasking preference inventory [86]. A 5-point Likert scale from 1 = strongly disagree (Finnish: täysin eri mieltä) to 5 = strongly agree (täysin samaa mieltä).

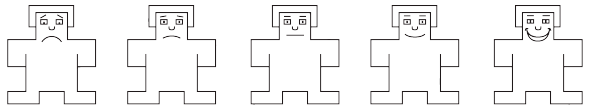
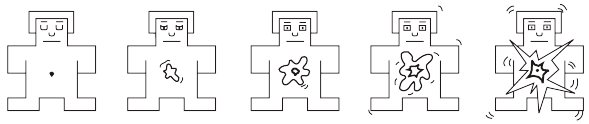
Item in English	**Item in Finnish**
1. I prefer to work on several projects in a day, rather than completing one project and then switching to another.	1. Työskentelen mieluiten usean projektin parissa päivittäin, sen sijaan että tekisin yhden projektin valmiiksi ja siirtyisin sitten seuraavaan.

2. I would like to work in a job where I was constantly shifting from one task to another, like a receptionist or an air traffic controller.	2. Haluaisin työn, jossa siirtyisin jatkuvasti tehtävästä toiseen, kuten vastaanottovirkailija tai lennonjohtaja.
3. I lose interest in what I am doing if I have to focus on the same task for long periods of time, without thinking about or doing something else.	3. Menetän kiinnostukseni tekemiseni kohteeseen, jos joudun keskittymään pitkiä aikoja ilman että ajattelen tai teen jotain muuta.
4. When doing a number of assignments, I like to switch back and forth between them rather than do one at a time.	4. Kun teen useita tehtäviä, vaihtelen ennemmin niiden välillä mieluummin kuin teen yhden kerrallaan.
5. I like to finish one task completely before focusing on anything else. (reversed)	5. Haluan saada yhden tehtävän päätökseen ennen kuin keskityn mihinkään muuhun.
6. It makes me uncomfortable when I am not able to finish one task completely before focusing on another task. (reversed)	6. Oloni on epämukava, jos en voi suorittaa yhtä tehtävää loppuun ennen kuin keskityn toiseen tehtävään.
7. I am much more engaged in what I am doing if I am able to switch between several different tasks.	7. Olen uppoutuneempi tekemiseeni, jos voin vaihdella usean eri tehtävän välillä.
8. I do not like having to shift my attention between multiple tasks. (reversed)	8. En pidä siitä, että minun tulee jakaa huomioni usean tehtävän kesken.
9. I would rather switch back and forth between several projects than concentrate my efforts on just one.	9. Vaihtelen mieluummin usean projektin välillä kuin keskitän ponnisteluni vain yhteen.
10. I would prefer to work in an environment where I can finish one task before starting the next. (reversed)	10. Työskentelisin mieluiten ympäristössä, jossa voin saada valmiiksi yhden tehtävän ennen kuin aloitan seuraavan.
11. I don't like when I have to stop in the middle of a task to work on something else. (reversed)	11. En pidä siitä, kun minun täytyy kesken tehtävän tehdä jotain muuta.
12. When I have a task to complete, I like to break it up by switching to other tasks intermittently.	12. Kun minulla on tehtävä suoritettavana, haluan jakaa sen siirtymällä ajoittain muihin tehtäviin.

13. I have a "one-track" mind. (reversed)	13. Ajattelen vain yhtä asiaa kerrallaan.
14. I prefer not to be interrupted when working on a task. (reversed)	14. En halua, että minua keskeytetään kun teen tehtävääni.

B.4 SAM

Table B.4: The self-assessment manikin (SAM). A 9-point pictorial Likert scale. Only 5 pictures were used and the remaining four options between the pictures were represented by black dots. The pictures in the valence scale represent valence from very negative in the left to very positive in the right, and the pictures in the arousal scale represent arousal from weakly arousing in the left to strongly arousing in the right. SAM was included in all conditions.

Item in English	**Item in Finnish**	**Pictorial options**
1. Assess negativity vs positivity. What kind of emotion did the TV program and the tablet content elicit?	1. Arvioi mielipaha vs. mielihyvä - millaisen tunteen äsken nähty TV-ohjelma ja tabletilla esitetty lisäsisältö herättivät sinussa.	
2. Assess emotional arousal. What kind of emotion did the TV program and the tablet content elicit?	2. Arvioi emotionaalinen aktivaatio - millaisen tunteen äsken nähty TV-ohjelma ja tabletilla esitetty lisäsisältö herättivät sinussa.	

B.5 TV program experience

Table B.5: The TV program experience questionnaire. A 7-point Likert scale from 1 = strongly disagree (Finnish: täysin eri mieltä) to 7 = strongly agree (täysin samaa mieltä). These items were included in all conditions.

Item in English	**Item in Finnish**
1. The TV program was interesting.	1. TV-ohjelma oli mielenkiintoinen.
2. The TV program was relevant to me.	2. TV-ohjelmalla oli merkitystä minulle.
3. The TV program was trustworthy.	3. TV-ohjelma oli luotettava.
4.The TV program provided novel information.	4. TV-ohjelma tarjosi uutta tietoa.
5. The TV program was understandable.	5. TV-ohjelma oli ymmärrettävä.
6. I liked the TV program.	6. Pidin TV-ohjelmasta.
7. I concentrated on the TV program.	7. Keskityin TV-ohjelmaan.
8. I immersed myself completely into the TV program.	8. Uppouduin TV-ohjelmaan täydellisesti.
9. I would share the TV program with my friends.	9. Jakaisin TV-ohjelman ystävilleni.

B.6 Additional information experience

Table B.6: The additional information experience questionnaire. A 7-point Likert scale from 1 = strongly disagree (Finnish: täysin eri mieltä) to 7 = strongly agree (täysin samaa mieltä). These items were included in Condition 3 and Condition 4, in which ADDINFO was presented.

Item in English	**Item in Finnish**
1. The additional information articles were interesting.	1. Lisätietoartikkelit olivat mielenkiintoisia.
2. The additional information articles were relevant to me.	2. Lisätietoartikkeleilla oli merkitystä minulle.
3. The additional information articles were trustworthy.	3. Lisätietoartikkelit olivat luotettavia.
4. The additional information articles provided novel information.	4. Lisätietoartikkelit tarjosivat uutta tietoa.

5. The additional information articles were understandable.	5. Lisätietoartikkelit olivat ymmärrettäviä.
6. I liked the additional information articles.	6. Pidin lisätietoartikkeleista.
7. I concentrated on the additional information articles.	7. Keskityin lisätietoartikkeleihin.
8. I immersed myself completely into the additional information articles.	8. Uppouduin lisätietoartikkeleihin täydellisesti.
9. The additional information articles added value to the TV program.	9. Lisätietoartikkelien lukeminen toi ohjelmaan lisäarvoa.
10. TV watching experience was enhanced by the additional information articles.	10. Katselukokemus oli miellyttävämpi, kun luin lisätietoartikkeleja.
11. The additional information articles were related to the TV program.	11. Lisätietoartikkelit liittyivät ohjelmaan.
12. The number of additional information articles was too small/large.	12. Lisätietoartikkeleja oli mielestäni...
13. The amount of additional information articles was too small/large.	13. Lisätietoa oli mielestäni...
14. Additional information was provided comprehensively.	14. Lisätietoa oli riittävän kattavasti saatavilla.

B.7 Multitasking experience

Table B.7: The multitasking experience questionnaire. A 7-point Likert scale from 1 = strongly disagree (Finnish: täysin eri mieltä) to 7 = strongly agree (täysin samaa mieltä) except for the items 4, 5 and 8. The item 4 was a 9-point scale where 1 = I looked only at the TV (katsoin pelkästään TV-ruutua) and 9 = I looked only at the tablet (katsoin pelkästään tablet-laitetta). The item 5 was also a 9-point scale where 1 = I looked only at the tweets (katsoin pelkästään twiittejä) and 9 = I looked only at the additional information (katsoin pelkästään lisätietoartikkeleja). The item 9 was a binary scale where 1 = the TV and 2 = the tablet.

Item in English	**Item in Finnish**	**Conditions**
1. I would have read tweets even without the tablet application.	1. Olisin seurannut twiittejä myös ilman tablet-sovellusta.	1, 2, 3, 4

2. I would have searched for additional information even without the tablet application.	2. Olisin hakenut lisätietoa myös ilman tablet-sovellusta.	1, 2, 3, 4
3. I struggled hard to be able to follow both the TV and the tablet.	3. Ponnistelin paljon pystäkseni seuraamaan sekä TV:tä että tablettia.	2, 3, 4
4. How much do you think you were looking at the TV and the tablet screens?	4. Kuinka paljon koit katsoneesi TV-ruutua ja tablet-laitetta?	2, 3, 4
5. How much do you think you were looking at the tweets and the additional information?	5. Kuinka paljon koit katsoneesi twiittejä ja lisätietoartikkeleja?	4
6. I felt that I couldn't concentrate on the TV because of the tablet.	6. Koin, että tabletti häiritsi TV-ohjelmaan keskittymistä.	2, 3, 4
7. I felt that I couldn't concentrate on the tablet because of the TV.	7. Koin, että TV häiritsi tablettiin keskittymistä.	2, 3, 4
8. I felt the main media was the TV/tablet.	8. Koin, että päämedia on...	2, 3, 4

B.8 Post-experiment questionnaire

Table B.8: The post-experiment questionnaire. A 5-point Likert scale from 1 = strongly disagree (Finnish: täysin eri mieltä) to 5 = strongly agree (täysin samaa mieltä) except for the item 1 which was an open-ended question.

Item in English	**Item in Finnish**
1. Describe how the tablet application felt.	1. Kuvaile, miltä tablet-sovellus sinusta tuntui.
2. I felt that the tablet application was useful.	2. Koin tablet-sovelluksen hyödylliseksi.
3. I felt I was connected to other Twitter users while using the tablet application.	3. Tablet-sovellusta käyttäessäni tunsin olevani yhteydessä muihin twitter käyttäjiin.

4. TV watching experience was more pleasant when additional content was presented on the tablet.	4. Katselukokemus oli miellyttävämpi, kun tabletilla näytettiin lisäsisältöä.
5. I felt that I couldn't concentrate on the TV because of the tablet.	5. Koin, että tabletti häiritsi ohjelmiin keskittymistä.
6. I felt that I couldn't concentrate on the tablet because of the TV.	6. Koin, että TV häiritsi tablettiin keskittymistä.
7. I would be eager to share my TV watching habits in social media.	7. Olisin valmis jakamaan TV:n katselutottumuksiani sosiaalisessa mediassa.